MODERN BUILDING PRACTICE

AN UP-TO-DATE AND PRACTICAL WORK DEALING WITH THE DESIGN, PLANNING, CONSTRUCTION, AND EQUIPMENT OF MODERN BUILDINGS

General Editor

PERCY E. THOMAS, Pres. R.I.B.A.

VOLUME III

MATERIALS AND OPERATIONS

Contributors to Volume III

RUSSELL LATHAM
T. CORKHILL, M.I.STRUCT.E., F.R.S.A.
H. R. MANSON
LLEWELLYN E. WILLIAMS, A.R.I.B.A.
N. B. LIVERSEDGE, A.M.I.C.E.
C. G. DOBSON, P.A.S.I., M.R.SAN.I.
C. W. TOMLINSON, F.R.I.B.A.
LIONEL PEARCE, A.R.I.B.A.
D. PARR
ROBERT J. JAY
LT.-COL. D. J. SMITH, O.B.E., M.I.A.E.
G. J. HANCOCK
P. J. LUXTON
T. E. DYER, A.I.B.C.C.
A. T. WINSTONE
S. HOWARD WITHEY, F.C.I.
NOEL D. GREEN
F. BUCKLEY HARGREAVES
S. C. MARRIOTT

GEORGE NEWNES LIMITED
TOWER HOUSE, SOUTHAMPTON STREET
LONDON, W.C.2

The Index to the subject-matter contained in this Volume will be found at the end of Volume IV.

PRINTED IN GREAT BRITAIN BY HAZELL, WATSON & VINEY, LTD., LONDON AND AYLESBURY

CONTENTS OF VOL. III

	PAGE
Introduction	1
Building Timbers	
Practical Notes on Hardwoods	4
Practical Notes on Softwoods	129
Notes on Selection, Marketing, Seasoning, Preservation, and Use	561
Fixing Metal Windows	17
Plaster and its Application	33
Bending Light-gauge Copper Tubing. Using the "Hilmor" Portable Bending Outfit	49
Wall Board Erection	53
Setting out a Building	76
Copper for Sanitary Work	81
Building a House, showing the Various Operations Stage by Stage	97
How to Fix Rubber Flooring and Rubber Stair Treads	145
Notes on Fixing Imitation Marble	158
Pressed and Moulded Glass	161
Practical Notes on Reinforced Concrete	177
Asphalte in Modern Building Practice	193
Useful Tables on Copper Pipes	207
Pitched Roof Coverings	
Part I.—Slates	209
Part II.—Wood Shingles	221
Part III.—Clay Tiles	225
Part IV.—Concrete Tiles	239
Part V.—Asbestos-cement	241
The Clerk of Works	
Part I.—Qualifications Required, Duties, and Conditions of Service	246

PAGE

THE CLERK OF WORKS—*continued*

PART II.—STATE OF WORK AND PROGRESS REPORTS AND RECORDS 257

PARTS III AND IV.—NOTES ON PRACTICAL WORK . . 264

BRICKWORK OPERATIONS

SETTING OUT, BUILDING AND POINTING WALLS, ARCHES, NOTES ON CRAFTSMANSHIP 289

PATHS. MATERIALS AND OPERATIONS 314

TIMBER FLOORINGS. MATERIALS AND OPERATIONS . . . 321

NATURAL STONES USED IN BUILDING

PART I.—CHOICE OF STONE—MARKETING—SURFACE FINISHINGS—LIFTING—SETTING STONEWORK 337

PART II.—FIXING AND SECURING BUILDING STONES—TESTING—PRESERVING—TYPES OF STONE 353

THE RECONDITIONING OF OLD BUILDINGS. 369

"VETTING" A PROPERTY 385

RECONSTRUCTED STONE 413

FURTHER NOTES ON REINFORCED CONCRETE FOR THE FOREMAN BUILDER 417

DOOR LOCKS. HOW TO SELECT AND FIT 433

SELECTING AND FIXING IRONMONGERY FOR WINDOWS AND FANLIGHTS 449

PRACTICAL NOTES ON PLYWOOD 465

RUNNING AND MAINTENANCE OF CONCRETE MIXERS . . . 478

BRICKS USED IN MODERN BUILDING 486

ASBESTOS-CEMENT IN MODERN BUILDING PRACTICE . . . 497

BUSINESS ORGANISATION FOR THE SMALL BUILDER . . . 511

QUANTITY SURVEYING 529

SURFACE TREATMENT OF CONCRETE 558

LIMES, CEMENTS, AND MORTARS 598

METAL SHOP FRONTS 605

DAMP-PROOFING AND WATERPROOFING 627

COLOURING OF CEMENT AND CONCRETE 635

MODERN BUILDING PRACTICE

VOL. III

MATERIALS AND OPERATIONS

INTRODUCTION

THE present volume is devoted to the materials used in building construction, and the various processes and operations which occur during the erection of a building—from the preparation of the site to the completion of the work.

We have found, during the preparation of this work, that it has not been possible entirely to separate the subjects of construction and operations. In dealing, for instance, with the technique of brickwork, which is, of course, one of the fundamental operations in building, one cannot ignore the different types of bonding, which also fall naturally under the classification of " construction."

From Raw Materials to Finished Products

In order to make the scope of the present volume clear to the reader, we would say that, whereas in Volume II—which is devoted mainly to the constructional side—the articles deal with finished details of building work, in the present volume will be shown the methods by which—starting from the raw materials of the builder—the finished result is obtained.

Wherever necessary, the whole process has been shown and described step by step, and to this end, a large number of special photographs have been secured to show clearly the correct sequence of operations.

Directly Useful Information

In dealing with the subject of building materials, every effort has been made to include information which can be put to practical use by the reader. In the case of timber, for instance, very little

FROM THE PREPARATION OF THE SITE—

Every process in the erection of a building—from a small house to a group of municipal offices—will be described and illustrated in the following pages.

—TO THE COMPLETED BUILDING

A typical example of modern domestic architecture, designed by Gertrude W. M. Leverkus, F.R.I.B.A.

space has been devoted to the purely botanical side, which, though of interest, is not of direct utility to the man who has to order or use timbers in his everyday work. Instead, the subject has been covered rather from the point of view of selection, cost, market forms, shipping marks, and methods of preservation. A similar style of treatment has been followed for other materials, such as bricks, natural and artificial stones and marbles, limes and cements, slates, tiles, and exterior and interior finishings.

In the case of cement and concrete, there are three distinct points of view, i.e. the designer's, the research worker's, and the builder's.

In view of the essentially practical nature of this work, we have not devoted very much space to the chemical and research aspects. They are, we believe, rather too specialised to be directly useful to the man in the building industry, and there are, moreover, several excellent books available for reference by those who wish to study the subject from either of these angles.

The Designer and the Craftsman

In this volume the subject of concrete and reinforced concrete has been treated with the object of enabling the craftsman to attain, as nearly as possible, the ideal conditions which are assumed by the designer when he prepares his plans on the drawing-board.

In view of the increasing extent to which steel-framed buildings are coming into use in this country, a considerable amount of space has been allocated to this subject, but here again it has been treated with the requirements of the builder in view.

The past few years have seen the introduction of several new types of roofing materials, wall coverings, flooring materials, fire-resisting materials and damp-proof materials and methods. All these are described in the following pages, and, wherever necessary, instructions are given as to the correct method of applying the materials to different types of structures.

Every man who is himself either a designer or a craftsman will, we believe, appreciate the practical treatment given in this section of the work.

BUILDING TIMBERS

PRACTICAL NOTES ON HARDWOODS

IT is amazing, but none the less true, that there are men in the building trades claiming from 20 to 40 years' experience of hardwoods who are being imposed upon daily through lack of exact knowledge, and yet any one of them would be seriously affronted if informed that the Cuban mahogany just acquired for certain special work was nothing more than hard-textured Honduras, and worth about half the price paid for it.

PRACTICAL NOTES ON HARDWOODS

Hardwoods may roughly be divided into three categories: home grown, imported Empire, and foreign. Unfortunately, the hardwoods indigenous to England are few in number, and for the most part uncommercial in quality. It is true that some of the finest old buildings in this country are panelled and decorated with English oak, and that English oak at its best is the finest and most durable of all oaks. Owing, however, to its slow growth, the wood is "strong" and often unreliable and unstable, and can never really be guaranteed "bone dry." There remain English ash, elm, chestnut, lime, and sycamore, etc., used in limited quantities for specialised purposes. The bulk of our hardwoods, therefore, for the building industries must be imported, and it is gratifying to feel that, thanks to the patriotism of merchants and consumers, the percentage from Empire sources is steadily increasing.

Method of Shipping Hardwood

Hardwoods are shipped to this country in several forms—in solid logs, in cut logs, in wainscot billets, and in square-edged boards and planks, and since it is so important a factor to the purchaser, it will not be amiss to devote some attention to grading.

Grading of Square-edged Lumber

The grading rules recognised in this country are based upon those drawn up in the United States of America by the Hardwood Manufacturers' Institute. They vary with different hardwoods as to specification, i.e. as to lengths and widths, but so far as standard defects permitted are concerned, the following may be accepted as a rough guide :—

Description of "Standard defects" in square-edged lumber (each of the following is considered to be one standard defect) :—

Fig. 1.—MEASURING WANEY-EDGED TIMBER

It is the custom of the trade to include in the measurement of the width one half of the wane.

Knots.—One knot not exceeding one and a quarter inches diameter. Two knots not exceeding in damage and extent one knot of one and a quarter inches diameter.

Splits.—One split not diverging more than one inch to a foot and not exceeding in length in inches the surface measure of the board in feet.

Wane.—Wane of one inch in width and not exceeding in length one-sixth of the length of the board.

Worm.—Not exceeding in extent or damage one knot of one inch and a quarter.

Grades

"Firsts," "Seconds," "Selects," "No. 1 Common," "No. 2 Common"—("Firsts" and "Seconds" in a proportion of approximately 60 per cent. of the former and 40 per cent. of the latter are offered for sale in Great Britain under the term of "Prime").

"*Prime*" ("Firsts" and "Seconds"—see note above).

"*Firsts*," 6 in. and up wide. Free from all defects, excepting that boards of 10 ft. or over surface measure may have one standard defect.

"*Seconds*," 6 in. and up wide. Standard defects are admitted according to the surface measure as follows:—

To 6-ft. surface measure 1 standard defect.
To 9-ft. surface measure 2 standard defects.
To 13-ft. surface measure 3 standard defects.
To 18-ft. surface measure 4 standard defects.

"*Selects,*" 6 in. and up wide. Must be equal to the grading of "Prime" on one face. The reverse face must not be below grading of "No. 1 Common."

"*No. 1 Common,*" 4 in. and up wide. Boards 4 in. wide must be two-thirds clear of defects, and no area between defects to cut less than 2 ft. long by the full width of the piece. Boards of 5 in. and over wide must work two-thirds clear and the area between defects to cut not less than 4 in. wide by 2 ft. long, or 3 in. wide by 3 ft. long.

"*No. 2 Common,*" 3 in. and up wide. There shall be no restrictions as to heart in this grade. Must work 50 per cent. clear of defect and the area between defects to cut not less than 3 in. wide by 2 ft. long.

Fig. 2.—TREATING FRENCH WALNUT WITH A SPECIAL PREPARATION AS A PRECAUTION AGAINST FUNGI AND "WORM" (LYCTUS BEETLE)

There are in addition other grades, such as "No. 1 Wormy," "No. 2 Wormy," "Shorts," "No. 3 Common," etc., but these qualities are usually too inferior to be considered for good-class work.

Grading of Solid Hardwood Logs and Billets

These are usually purchased by description or on inspection.

METHOD OF MEASURING HARDWOODS

Square-edged Lumber

In thicknesses of 1 in. and under, square-edged lumber is measured at per foot super, in thicknesses of $1\frac{1}{4}$ in. and up at "per foot super of 1 in." To obtain the superficial feetage the length in feet is multiplied by the width in inches and divided by 12—i.e. a board 10 ft. long and 9 in. wide $= 10 \times 9 \div 12 = 7\frac{1}{2}$ ft. super. To reduce thicknesses above 1 in.

to feet super of 1 in., the superficial face measure is first reckoned and the result is multiplied by the thickness, i.e. a plank 10 ft. long, 9 in. wide, and 1½ in. thick = 10 × 9 × 1½ ÷ 12 = 11¼ ft. super of 1 in., or a plank 8 ft. long, 12 in. wide, and 3 in. thick = 8 × 12 × 3 ÷ 12 = 24 ft. super of 1 in. It is the practice in this country to mark the contents on the board or plank in Roman figures.

Log-sawn Boards and Planks

The procedure here is similar to that in square-edged lumber, but with this exception—log-sawn timber is irregular in width and has " waney " edges. To obtain a fair width, therefore, boards and planks are measured in three places, viz., at 6 in. from each end and at the centre, and the average struck. Further, each width is taken over one-half of the wane, so that the loss involved in consequence of the waney edges is shared between the merchant and the consumer.

Measurement of Solid Squared Hardwood Logs

Imports of these are largely mahogany, African teak, and Nigerian walnut, and are measured either out to their full contents or to what is known as " Liverpool Sale Measure." The full contents are obtained by multiplying the length by the width and the resultant figure by the depth. The total divided by 12 represents the feet super of 1 in. thickness—i.e. a square log 16 ft. long, 24 in. wide, and 22 in. deep = 16 × 24 × 22 ÷ 12 = 704 ft. super of 1 in. In Liverpool Sale Measure the measurements are taken in the same manner, but a special allowance of 1½ in. is made in every 12 in. in both width and depth, for example, a log 24 in. wide by 22 in. deep would be reckoned as only 21 in. wide by 19¼ in. deep. The difference between the full contents and Liverpool Sale Measure is from 25 per cent. to 33⅓ per cent. Certain allowances are made for serious defects, such as faulty ends, etc.

Measurement of Solid Round Hardwood Logs

Round logs are measured by the Hoppus quarter-girth system. In logs which are reasonably straight from butt to top the tape rule is taken round the log at the centre to ascertain the circumference. In logs of diminishing girth two measurements are taken and an average struck. The circumference divided by 4 will give the quarter girth. Multiply the length of the log by the quarter girth twice in inches and divide by 113 and the result will be the full actual contents in feet cube. Example —a round log 12 ft. long by 60 in. circumference equals 12 ft. by 15 in. quarter-girth = 12 × 15 × 15 ÷ 113 = $23\frac{10}{113}$ ft. cube. It will be noted that the divisor of 113 gives the " full contents," but in trade circles the divisor generally used is 144, which makes the purchaser some allowance for unsuitable wood, so that a log of the dimensions shown above works out rather more advantageously, as follows, 12 × 15 × 15

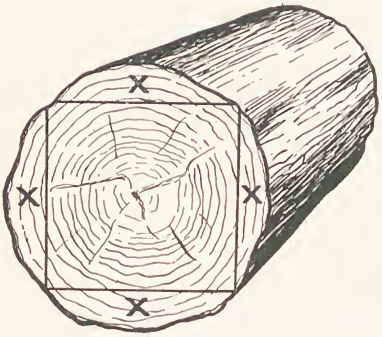


Fig. 3.—SHOWING MEASUREMENTS BY HOPPUS QUARTER-GIRTH SYSTEM

The square within the log represents the sale measure, using 144 divisor.

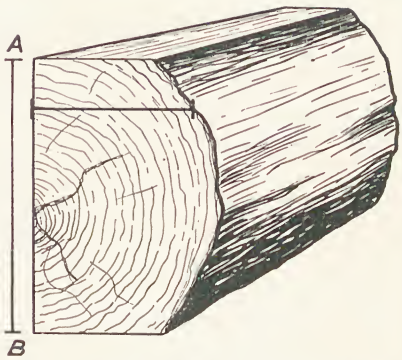


Fig. 4.—METHOD OF MEASURING WAINSCOT BILLETS

The width is taken at a fair average point, as shown.

$\div$ 144 = 18¾ ft. cube. When buying round logs on the Hoppus system of measure, therefore, insist upon the divisor of 144. On logs with a heavy thick bark, such as oak or ash, a concession of 10 per cent. is made, or on beech, sycamore, etc., where the bark is thin and tight, one of 5 per cent.

Measurement of Wainscot Billets

These are measured with callipers, the width being taken at a fair average point, and multiplied by the height from A to B, and again multiplied by the length—the total divided by 12 gives the feet cube. Allowance is made for serious faults and defects, and this is most necessary in the case of those billets which are produced by the splitting of a round log into halves, since the centre adzed face will often have been deeply gouged and channelled consequent upon the removal of knots.

HOME-GROWN HARDWOODS

Ash (English)

The ash tree is to be found in considerable quantities throughout the temperate zones of the Northern Hemisphere, but the British ash (*fraxinus excelsior*) is perhaps unequalled for toughness and elasticity. Do not be misled into buying "a fine old dry parcel of ash boards and plank"—it will probably be too dry! Whereas most hardwoods improve with age, ash reaches its best condition when seasoned for about nine to twelve months per inch of thickness. Therefore, after, it quickly deteriorates and becomes light and "corky."

Beech (English)

Used in considerable quantities for upholstered chair and settee frames, and the best growths are produced on soils of a chalky description.

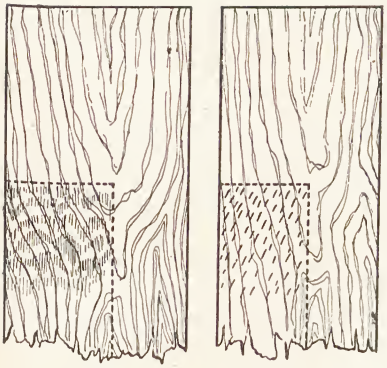


Fig. 5.—How to distinguish between Honduras and African mahogany

A close inspection will reveal minute flecks. The above shows Honduras on the left and the African variety on the right.

Some of the finest beech is to be found in Buckinghamshire, and it is natural, therefore, that High Wycombe should have become the centre of the chair industry.

Chestnut (English, Sweet)

A hard and very durable wood, closely resembling plain sawn oak. Examples of old floors and Jacobean furniture made in chestnut are fairly common. Chestnut is very much subject to a defect known as "ring shakes," and care should be exercised in buying uncut logs.

Elm (English)

Recently a new technique of seasoning elm has been discovered, which renders it suitable for flooring and interior joinery as well as for exterior work and foundations.

Lime (English)

The lime tree is not indigenous to this country, but it has been planted freely. The wood is close-grained and soft, and comes clean from the tool, and in earlier times was largely used for carving, notably by Grinling Gibbons.

Oak (English)

This type of oak has many excellent characteristics: it is hard, unusually durable, and of a more pleasing appearance than any other oak, not excepting the finest "Austrian," but it should be treated with every care and respect or it will prove very troublesome. Unquestionably the milder European or American oaks are more suited to the work of the cabinet maker. Owing to its slow growth and dense texture, no period of seasoning, however long, will render English oak boards and planks "bone dry," and immediately fresh surfaces are exposed during planing and preparation the process of shrinking and twisting commences once again. Instances are known of English oak panelling which has been fixed for upward of 200 years, and which after being removed and cleaned up has "buckled." English oak is available in "butts," i.e. round logs which are sawn through and through the centre, wainscoted billets, and very occasionally square-edged boards and planks. The wainscoted billets are substantially the most expensive, but it should be borne in mind that they have one square edge and the additional cost would probably be more than compensated for by the reduced waste in conversion. In using English oak for flooring it is advisable that the thickness is of not less than $1\frac{1}{4}$ in. nominal.

Sycamore (English)

Of a fine white colour for interior decoration, but it should be seasoned with unusual care or it will become discoloured. Sycamore should be purchased if possible from sawn logs standing in racks, since boards which are piled horizontally with "sticks," after the manner of other hardwoods, are liable to become stained where dirt and water have collected along the sticks. The stains may sometimes be removed with oxalic acid, but more often they will have percolated deeply into the wood.

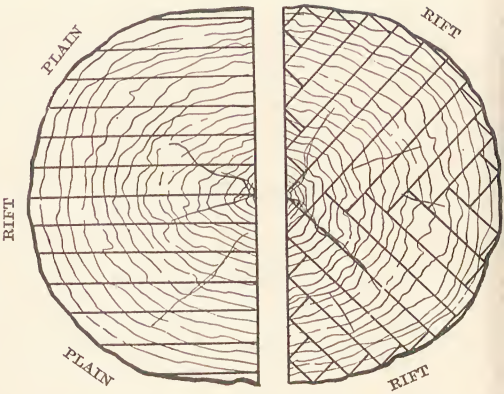


Fig. 6.—PLAIN AND RIFT OR QUARTER-SAWN TIMBER

IMPORTED EMPIRE HARDWOODS

African Mahogany

Under this comprehensive term is roughly included all those mahoganies obtained from the West Coast of Africa. Now the West Coast of Africa has a forest area which extends some 2,000 miles north and south, which ranges through tropical, sub-tropical, to almost temperate zones, and which comprises no small change in soil, so that it is not unnatural to expect a wide variation of mahogany growth and texture. For purposes of classification, therefore, logs are usually described by their port of shipment.

Thus we have Lagos and Benin from Nigeria, Secondee and Axim from the Gold Coast, Grand Bassam from the French Ivory Coast, and Cape Lopez from French Congo. Such a richness of choice is somewhat disturbing to the user, but for first-class work, and quite apart from Empire sentiment, he cannot do better than purchase Lagos or Benin. Lagos and Benin mahoganies are the most closely akin to the more expensive Honduras wood; they are of tight grain and fine firm texture, and with reasonable care in selection they are free from the slight "woolliness" to be found in some African mahoganies. A defect to be guarded against in purchasing African mahogany is known as "thunder shake," i.e. the fibres of the wood are ruptured across the grain, and the trouble is not readily apparent in sawn boards without a careful scrutiny.

Honduras Mahogany

Formerly called "Baywood" from the fact that it emanated from the hinterland of the Bay of Belize. More recently the expression

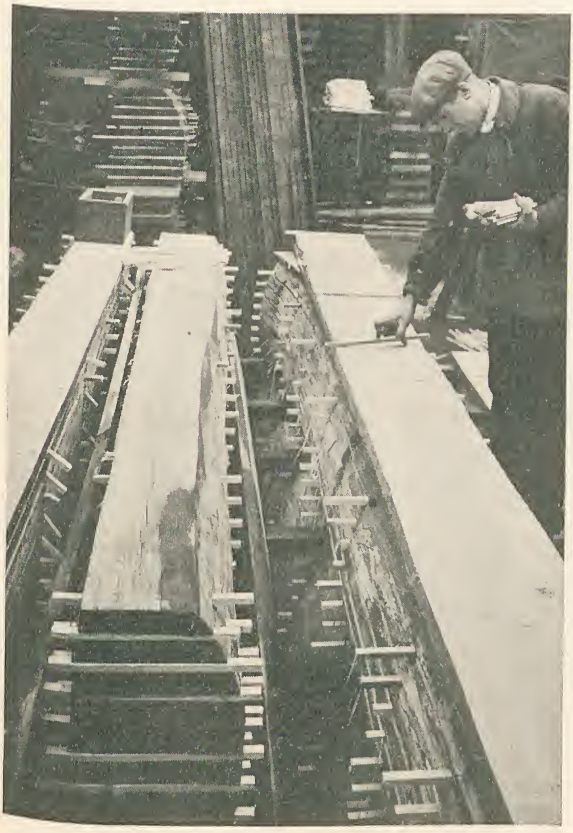


Fig. 7.—"STICKING" WAINSCOT OAK BILLETS
Note that all "sticks" are freshly cut and new—dirty sticks stain the wood.

"Honduras" has become very much misused until it now covers Nicaraguan, Mexican, Peruvian and in fact almost any of the Central and South American mahoganies acquired by mills in the United States of America, and converted into square-edged lumber for shipment to the British Isles. In consequence of this abuse a parcel of square-edged "Honduras" shows a considerable variation of texture and colour, and preference should be given to sawn logs of specified origin. Since these types of mahogany are not always readily distinguishable from the best West African, and there is a difference of 33⅓ per cent. in cost, it is well to look for some peculiar but not generally known characteristic. A close inspection will disclose in both Honduras and African mahoganies a minute fleck as though the wood had been lightly touched, countless times, with a sharply pointed pencil. In African mahogany these flecks are placed promiscuously, whereas in Honduras Nature has ordained that they are lined up horizontally across the grain, like precisely drilled battalions of soldiers (see Fig. 5). A further point—Honduras mahogany logs are hewn square throughout their whole length, while most African logs have a "keel" or rounded end which is adzed off to facilitate manhandling through the dense African bush. Since the application of import duties, Honduras mahogany is shipped in increasing quantities direct from British Honduras.

Cuba and Tobasco Mahoganies

These and other foreign hardwoods are dealt with in a later section.

Fig. 8.—PILING WAINSCOT BILLETS FOR SEASONING

Teak, Moulmein, Rangoon or Burma (Tectona Grandis)

This is probably the most valuable of all hardwoods, and for the manufacture of joinery destined for tropical countries it has no equal, for it is uncongenial to the depredations of the white ant. Teak is known to have been used for at least 2,000 years, and was referred to in the Dravidian language as "teka"—the Portuguese of the Middle Ages called it "teke," whence is derived the English name. In proof of the exceptional durability of teak, explorers recently found, in a palace of the Persian kings near Bagdad, pillaged in A.D. 760, a number of baulks of teak in practically perfect condition. There is on the Persian Gulf an ancient town called Siraf, which is of peculiar interest, inasmuch as it is built entirely of teak. Teak is very dense in texture, as will be realised by the fact that it weighs 50 lb. to the cubic foot.

Teak is mostly sold in square-edged boards and planks, averaging about 9 ft. long and 9 in. wide. It is available in larger sizes, but prices rise very steeply indeed, and ignorance of this is liable to lead to difficulty on a fixed estimate. As a rough guide, a shilling per foot cube should be added to the basic rate for each additional inch in width above 9 in., and 6*d*. per foot cube for each additional foot in length.

For example, a 9-ft. × 9-in. board may be quoted at 15*s*. per foot cube,

Fig. 9.—A SHIPMENT OF SQUARED AFRICAN MAHOGANY LOGS
This is a first-class and remarkably sound parcel.

so that one of 9 ft. × 10 in. is worth 16*s.* per foot cube, one of 10 ft. × 10 in. is worth 16*s.* 6*d.* per foot cube, and so on. It will thus be appreciated that a counter top of 18 ft. × 20 in. must be reckoned at the considerable rate of 30*s.* 6*d.* per foot cube.

Only the best teak is shipped to this country, in the grades of "prime" and "intermediate." The lower grades are used for local consumption in India, Burma, and Siam.

African Teak (also called "Iroko," sometimes "African Oak")

This is not a genuine teak, but it has an appearance sufficiently similar to be used for some purposes as a substitute. It is especially to be recommended for draining-boards of large width, and will show the purchaser an advantage of between 33⅓ and 50 per cent. over its Indian counterpart. There is some slight difference in the texture as between the male and female tree. African teak is mostly available in the form of squared logs of about 20 in. to 36 in. wide, sawn to various thicknesses, although recently square-edged boards have appeared on the market.

Indian Silver Greywood

One of the newer Empire hardwoods, the merits of which deserve to be better recognised. It is of a general grey-brown colour, heavily

marked and streaked with black. Available in square-edged boards and planks from 6 ft. to 16 ft. long, and 6 in. to 14 in. wide, or alternatively, log-sawn. The sapwood of the tree from which Indian silver greywood is produced is known as " chuglam," and should be avoided, as it is of pale colour, insipid, and uninteresting.

Larana Whitewood

A West African (Empire) timber, of considerable versatility. It may be employed for any purpose for which the foreign American whitewood would formerly have been used, or again, when stained and suitably polished, it is an excellent cheap substitute for mahogany. Larana whitewood is of an even, yellowish white colour, and is available in square-edged boards of from 6 in. to 36 in. wide, and from 6 ft. to 24 ft. long. It may be especially recommended for shop fascias on account of its large dimensions. In purchasing ensure that the texture is reasonably firm, as some logs, especially those from French West Africa, are inclined to be rather soft.

Australian Walnut

This is not a genuine walnut, although it bears some resemblance to American walnut. The colour is purplish-olive rather than purplish-brown. Many boards are marked with a pleasing " mackerel " figure. Australian walnut is somewhat hard in texture, and the cost of machining and conversion is in excess of that of American walnut, but of late it has become extremely popular. Available in square-edged boards and planks from 6 ft. to 16 ft. long and 6 in. to 14 in. wide.

Black Bean (Australian)

A timber which has been used fairly largely in the shipbuilding yards of the north for high-class cabin and saloon fittings during recent years. In appearance it resembles somewhat African teak, but the colour is deeper and more brown. Australian black bean is of very dense texture and of considerable weight, and is to be obtained in square-edged boards and planks of from about 6 in. to 12 in. wide and 6 ft. to 16 ft. long.

Silky Oak (Australian)

Of a biscuit colour, and when cut on the quarter it has the appearance of quarter-cut beech with the " fleck " magnified many times. Silky oak is rather insignificant and dull, but if relieved by the use of some other more distinctive hardwood, such as walnut, it may be made quite attractive.

Maple (Canadian)

The main interest of Canadian maple to the builder is for flooring, and for this purpose it is greatly esteemed on account of its light colour. At

the same time, the colour is liable to be a deception and a disappointment. Maple is not white, as is commonly supposed, but even in the highest grades will carry a certain amount of brownish-grey wood. Further, a percentage will be marked with a bird's-eye figure, which detracts rather than otherwise from the appearance of a floor. In tendering, therefore, for a maple flooring, do not stress too much the point of colour.

HARDWOODS

(Comparative Average Costs—Figures are ciphers only)

Ash (English)	10	Oak (Volhynian)	13
Beech (English)	7	Oak (Japanese)	10
Black Bean (Australian)	18	Oak (American)	10
Chestnut (English, Sweet)	8	Oak (Australian Silky)	16
Elm (English)	5	Silver Greywood (Indian)	16
Larana Whitewood	7	Sycamore (English)	18
Lime (English)	14	Teak (Moulmein, Rangoon, or Burma)	14
Mahogany (Spanish)	36	Teak (African)	11
Mahogany (Cuba)	21	Walnut (Australian)	16
Mahogany (Tobasco)	18	Walnut (English)	18
Mahogany (African)	11	Walnut (French)	18
Mahogany (Honduras)	15	Walnut (Italian)	18
Maple (Canadian)	10	Walnut (American)	21
Oak (English)	15		
Oak (Slavonian)	15		

ESTIMATED WASTE IN CONVERSION OF HARDWOODS

Of great importance to the builder is the question of what waste to estimate in converting the raw material into finished joinery dimensions. On this knowledge may perhaps depend the securing or losing, in competition, of an order.

Obviously, pertinent factors are the form in which the timber is purchased—i.e. whether in boards taken from round logs, adzed-square boards from square logs, square-edged lumber, or boards from wainscoted billets—and also the grade. Hardwoods of " prime " grade are the most economical in the long run, and to avoid undue detail we will assume that they are employed.

Boards taken from round logs have considerable wane, and every log has inevitably some fault round the centre, so that a wastage of between 25 per cent. and 33⅓ per cent. should be allowed.

Square logs, on the other hand, have less wane, and the waste may be put at from 20 per cent. to 25 per cent.

Prime square-edged boards and planks are almost free from defect, and the loss should be kept within from 10 per cent. to 15 per cent.

There are, naturally, exceptions to the percentages mentioned, for

some woods are excessively faulty, and particular care should be used in dealing with English oak, English walnut, and to a lesser degree French, Italian and Ancona walnut.

SEASONING OF HARDWOODS

In purchasing hardwoods for high-class joinery it is essential to make quite sure that they are fully seasoned, or trouble will arise from shrinkage. It is reckoned that the period required to render hardwoods commercially dry is at the rate of a year per inch of thickness, i.e. a half-inch board will take six months, whereas a plank of 3 in. would take three years. There is a difference of opinion in the matter of kiln drying, but there is no doubt that " natural " drying is to be preferred.

Hardwoods are often offered " in a shipping dry condition," which means that, after the material has been converted in its country of origin, it has been placed on sticks for two or three months to prevent it " sweating " or becoming " doaty " in transit.

It is consequently unwise to obtain " shipping dry " parcels for immediate use.

Some "Don'ts" for the Timber Buyer

The following " Don'ts " may be the means of saving money and difficulties to the hardwood timber buyer. There are pitfalls which seem to beset even the most experienced.

Don't order larger sizes than those actually required—larger sizes in hardwoods are not only very much more expensive than those which are smaller, but obviously they limit the merchant's scope in selection—for example, if the framing for the panelling in your contract is to come out of 1-in. × 4-in. wood, then state the correct size of 1 in. × 4 in. on your order and not a multiple, such as 1 in. × 8 in. or 1 in. × 12 in. You will thereby save anything from 10 per cent. to 20 per cent. in price.

Don't, for preference, purchase 1-in., 1¼-in., 1½-in., or 2-in. square-edged imported boards and have them re-sawn to some thinner thickness —the outside surface of the resultant thin boards will be drier than the inside re-sawn surface, and " casting " is almost inevitable.

Above all, remember that hardwood timbers are grown with natural and unavoidable faults and defects, and that they are not manufactured.

Later articles will deal in detail with Foreign Hardwoods, Softwoods, Veneers, and Plywoods, and with Wood Preservation.

FIXING METAL WINDOWS

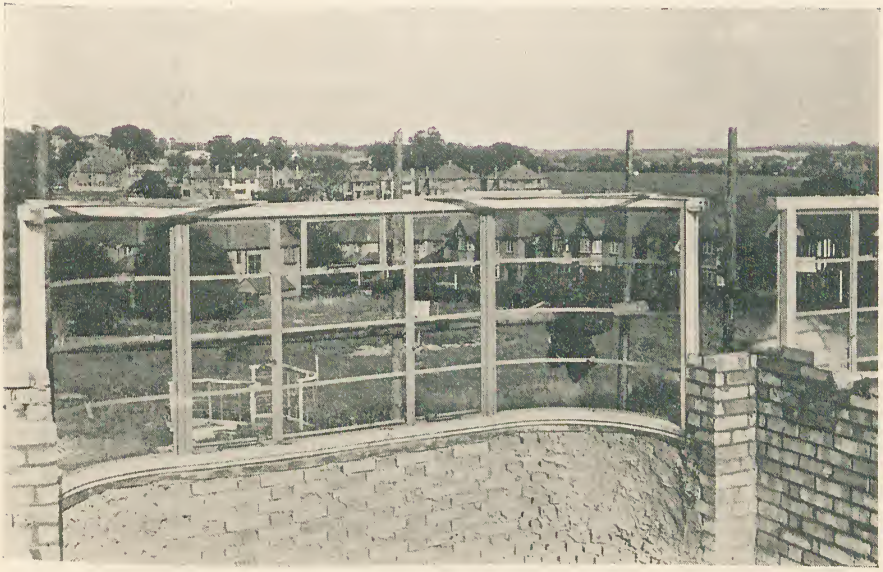


Fig. 1.—Curved metal casement bay window with wood surround
The use of the wood surround renders the fixing of this type as simple as that of a wood casement window.

METAL windows have firmly established themselves as an alternative to almost any type of wood window, including cased frames. The result is that the onus is upon everyone actively interested in the building industry to become acquainted with the new conditions due to their use.

What are Standard Windows?

Windows constructed upon certain unit principles such as size, design, and methods of glazing have led to the standardisation of those most suitable for everyday requirements of the building industry.

Fig. 2, while not depicting all the types of standard windows, gives a very good idea of the principles adopted. For example, one can readily see that differing designs and widths are made in standard heights, a point that facilitates the designing of an elevation where the height of windows must be uniform. Or, again, differing designs and heights are

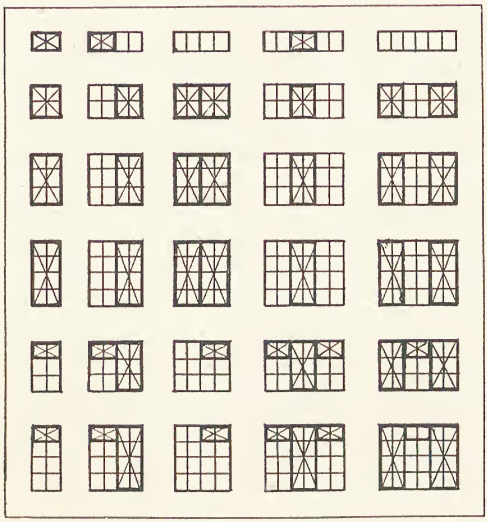


Fig. 2.—SOME OF THE TYPES OF STANDARDISED METAL WINDOWS

This illustration shows the principles of standardisation of sizes, widths, and types. The crosses denote opening portions.

made in uniform widths, for use in elevations requiring this type of treatment.

Other features of standardisation are glazing and handing. Under the first, windows are made with or without glazing bars, to enable the use of leaded lights or large panes as desired. The second has been rendered necessary from the point of view of balancing the design and the necessity of being able to open a window in opposite directions.

Special Types and Sizes

Metal windows can be made to special sizes if required and also to special types differing from standard construction. Openings can be placed in any positions to suit the particular buildings for which they are intended.

A case in point is the ground floor of a school where windows of the ordinary side-hung types opening outwards to a playground would be very dangerous if the cills were less than 6 ft. from the ground. To overcome this difficulty a type of window, bottom hung, opening inward to a restricted angle, can be made.

Factory Sashes

The modern forms of factory and similar buildings call for exceptionally large window space, and to supply this need special metal windows are made known as "factory sashes." They differ from the domestic types in several features, mainly in their size and method of ventilating, for it will be seen that while it is simple to fit an ordinary house with windows having the whole of one or two of their sashes to open, this would not be practical with windows having a height of anything up to 9 ft., by 5 ft. or 6 ft. wide. The difference between these types of windows is shown by the domestic window in Fig. 3 and the factory sash in Fig. 4.

METAL WINDOWS

Why a Metal Frame is Watertight

Fig. 5 is a section through a wood casement and explains how water is kept from percolating to the interior of the window by its construction

Something of this principle is used in the manufacture of metal windows, and Fig. 6 shows a section through a similar opening casement made of metal by which the same watertight result is obtained. The outer frame "A" bears hard upon the inner frame "B", thereby sealing the opening. The spaces marked "C" act as check grooves. The illustration in Fig. 6 is an outward - opening type. The same watertighting principle is used with regard to inward-opening types, where it concerns the head, but the bottom edge must be fitted with a weather bar as shown in Fig. 7.

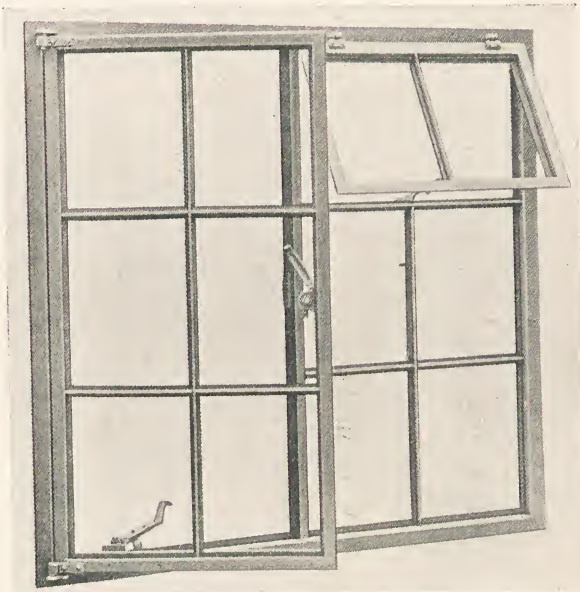


Fig. 3.—A "STANDARD" TYPE DOMESTIC WINDOW
This is of the outward-opening type with night vent and fitted with glazing bars.

Fixing Windows Direct in Brickwork

In most building works it is the carpenter's job to prepare the windows and to offer them into position for the bricklayer to build up to. He must therefore be conversant with the methods by which the whole opening is rendered watertight in addition to the opening sashes as explained above.

Fig. 8 is a typical detail of a metal window fixed between walls showing the construction at one of the jambs. These windows are supplied with steel lugs on all four sides to be embedded in the brickwork.

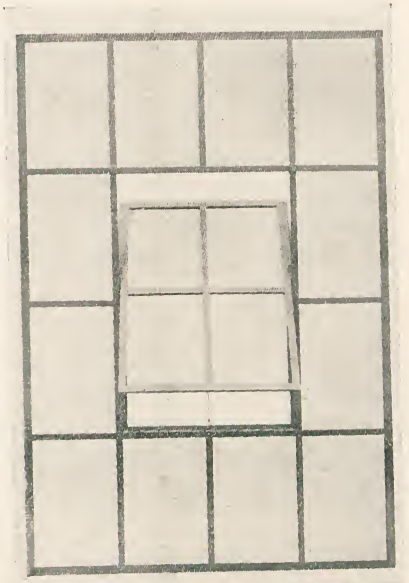


Fig. 4.—A "STANDARD" TYPE FACTORY SASH WITH CENTRE-HUNG VENTILATOR

Fixing as Work Proceeds

Having placed the window in position and being assured that it is

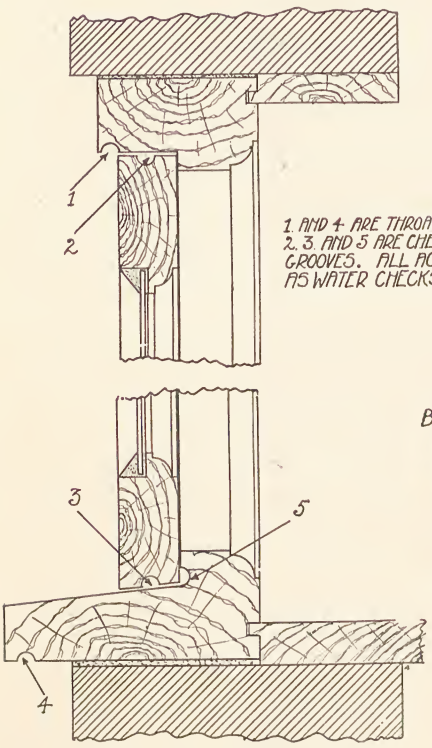


Fig. 5.—SECTION THROUGH A WOOD CASEMENT

The throats and check grooves shown are designed to prevent water entering by capillary attraction, the first by causing the water to drip before reaching the adjacent surfaces and the second by interrupting the capillary tube.

Making Opening Watertight

When the work is completed the whole opening is rendered watertight by means of the cement fillet as shown in Fig. 8. This is bedded in by the bricklayer as the work proceeds, and by the mastic pointing between the steel frame and the brick jamb.

Where the windows are perfectly vertical, it must be held in this position by means of a temporary strut fixed obliquely. This precaution, of course, is only necessary where the windows are being built in as the work proceeds, for the windows can be inserted in prepared openings left in the brickwork, although this method, besides being more costly, is likely to result in the openings being a fraction too large or too small to ensure a good fit.

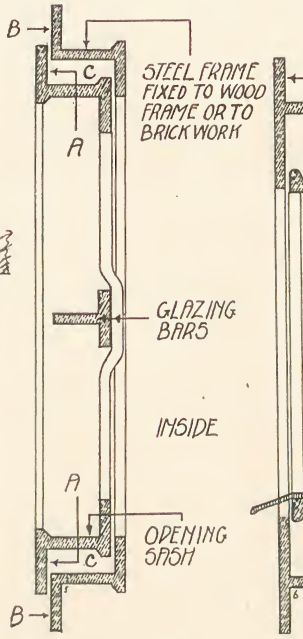


Fig. 6.—SECTION THROUGH AN OUTWARD-OPENING METAL WINDOW

The capillary attraction referred to in Fig. 4 would occur between surfaces A and B, but water is prevented from reaching the interior by the check C.

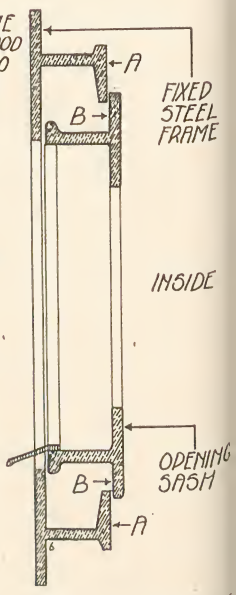


Fig. 7.—SECTION THROUGH AN INWARD-OPENING METAL CASEMENT

To prevent water entering, the bottom edge must be fitted with a weather bar as shown.

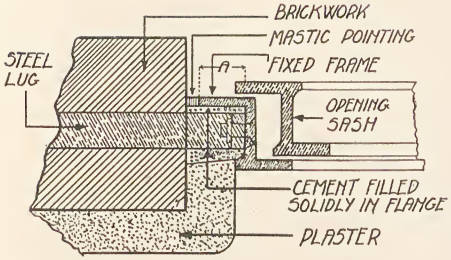


Fig. 8.—FIXING THE WINDOW BETWEEN WALLS

The flange must be fitted solid with cement and the mastic pointing carefully inserted.

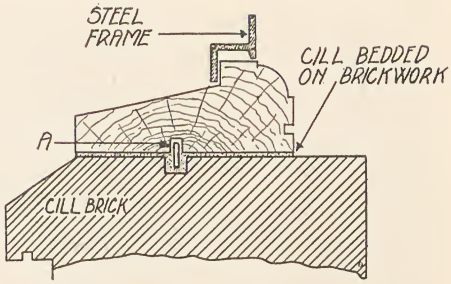


Fig. 9.—A WOOD CILL SET BEHIND THE FACE OF BRICKWORK

The cill must be bedded on a cill brick or stone cill which must project to allow the throat to overhang the brickwork.

inserted in prepared openings, great care must be taken to see that the frame is properly bedded with the cement fillet, as this is frequently omitted in slovenly work and often leads to a great deal of trouble.

Head of Frame Should Bear no Weight

It should be noted here that the head of the frame should always be prevented from carrying any weight, and the lintel, steel joist, brick arch, or whatever method of construction is used should be so built to avoid this. Even the slightest sinking may tend to buckle the frame and thereby break the joint and allow the ingress of water.

Wood Cills and How to Fix Them

When the windows are built direct to brickwork there are various forms of cills that can be used. One is a wood cill which is bedded direct on brickwork before the insertion of the window, and this in its turn can be fixed in various ways. Fig. 9 shows a cill set back from the face of the brickwork, and it will be seen that if the water bar "A" is omitted rain water is likely to percolate between the joint and so find its way to the interior of the building. If the cill is grooved and a metal bar, preferably galvanised, is inserted, the ingress of the water is retarded.

A cheaper form of construction can be made by carefully bedding this groove on a cement bed, at the same time ensuring that the groove is completely filled with the cement, which, provided it is properly done, forms an efficient water check.

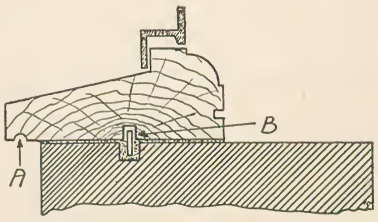


Fig. 10.—DIAGRAM SHOWING CILL SET PROJECTING

In this case the wood cill projects and requires the throat formed on its under side.

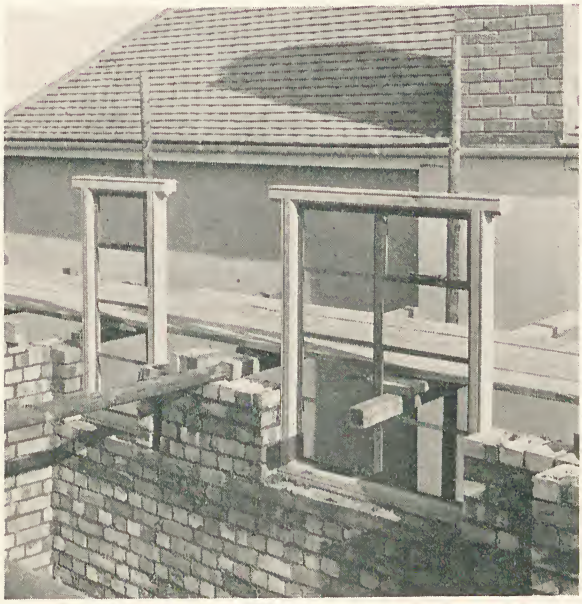


Fig. 11.—METAL CASEMENT WINDOWS IN POSITION

When it is required to set a wood cill behind the face of the brickwork, either a stone or tile cill or cill brick must be used in conjunction, as is shown in Fig. 9.

Another Method of Fixing Cills

Another method of fixing the cill is shown in Fig. 10. In this case the cill projects beyond the face of the brickwork. It is essential that the throat "A" be formed on the under side as shown, and it is advisable that the water bar "B" is inserted.

Wood cills should be formed as shown with a ½-in. external rebate to form a bed for the metal window, and should be well weathered. Too often is the scarcity of weathering found to be the cause of many water troubles with window fixings.

Stone Cills

The same method of construction and fixing applies equally to stone cills, the only difference being that these should be carefully plugged opposite the respective fixing holes with hardwood plugs.

When the cills are in position and are set, the windows should be bedded by filling the channel of the frame with a special mastic supplied with them and the whole pressed against the rebate. The screws can then be inserted, care being taken not to twist the frame in the process.

Fixing Windows with Tile Cills

Another method of forming a cill, mostly used where windows are built direct into face brickwork or into rough-cast work, is by means of tiles. Where these are used they should be laid first and allowed to set. The windows should then be placed in position and cement grout poured through the fixing holes.

An alternative method is to see that the channel is well filled with cement mortar and the frame pressed well down to make a firm bed before fixing screws are inserted. When the frame is fixed in this manner

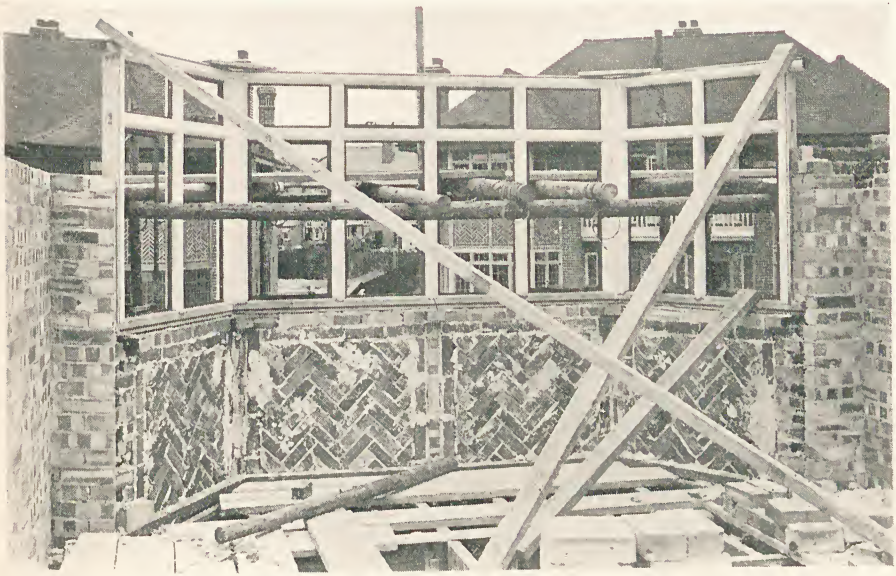


Fig. 12.—WOOD BAY FRAME WITH METAL CASEMENT BRACED READY FOR FIXING

it is very difficult to use the fixing lugs which are supplied with the windows. The writer has found by practical experience that it is better to poise the window on blocks and build in the lugs in the brickwork of the jambs only, leaving sufficient space on the under side of the window for the tiles to be inserted later.

Tile cills can also be fixed when wood frames are used.

Fixing the Tiles

This is a point to which particular attention should be paid. Examine Fig. 14 and notice that the tiles are laid with a considerable slope; this is to avoid rain remaining on the surface and being driven inward by means of the wind between the edge of the window frame and the tile, should the pointing at any time become loose.

The overhang of the tile beyond the face of the brickwork should be at least 1 in. to $1\frac{1}{2}$ in., and preferably the lower tile should be of the continuous nib type, the nib acting as a drip to prevent the water finding its way along the under side.

Types of Frames to Use in Rough-cast Walls

So far the types of windows that have been explained are manufactured of a standard width of section—that is, the distance shown at "A," Fig. 8, is usually about $\frac{3}{4}$ in. When the wall is to be rough-cast this distance is insufficient, as the distance between the walls is reduced by about 1 in. or the thickness of the rough-cast on either jamb, the rough-cast in its turn

Fig. 13.—THIS PHOTOGRAPH SHOWS HOW THE ANGLE-IRON TIE IS INSERTED IN THE CORNER OF A BAY OVER A METAL CASEMENT WINDOW

interfering with the action of the hinges. To overcome this a window is manufactured with what is known as a wide or long flange, and in these the width "A" referred to is increased by ½ in. It is necessary to state this when ordering windows to be used under these conditions.

Fixing Window Boards

The method of fixing window boards where metal windows are used depends largely upon the type of cill that has been fitted. Fig. 15 is an illustration of the fixing used where the window was built direct between walls to be rough-cast, and in which the internal reveals are to be plastered.

A good fixing to the brickwork beneath is obtained by driving properly shaped wood wedges between the joints and nailing the window board thereto. A good finish can be obtained at the corners by allowing it to run by and returning any moulding appearing on the front edge. The plaster is then brought down on top of the board. Fig. 15, however, shows another method—that is, to fit the board between the jambs, so that when the wall and reveals are plastered the slightly rounded edge projects beyond the plaster.

As there may be a tendency for window boards to warp slightly, due to dampness through an open window, the worst case being in an upward direction, the joint between the under side of the board and the plaster

can be covered by a small moulding tongued to the under side and which in the case of slight warping would move with the board and yet still cover the joint.

Fixing with Breeze Bricks

Another method of securing a good fixing for window boards is to see that proper breeze fixing bricks are built in, say, at 18-in. intervals along a perfectly level surface. The boards may then be spiked to these bricks, the nails being driven in obliquely.

Where a wood cill is used the back edge should be rebated to receive a tongue on the back edge of the board. The wedges are driven between the brickwork as before to form a further fixing, and the brickwork is brought up level with the under side of the window board.

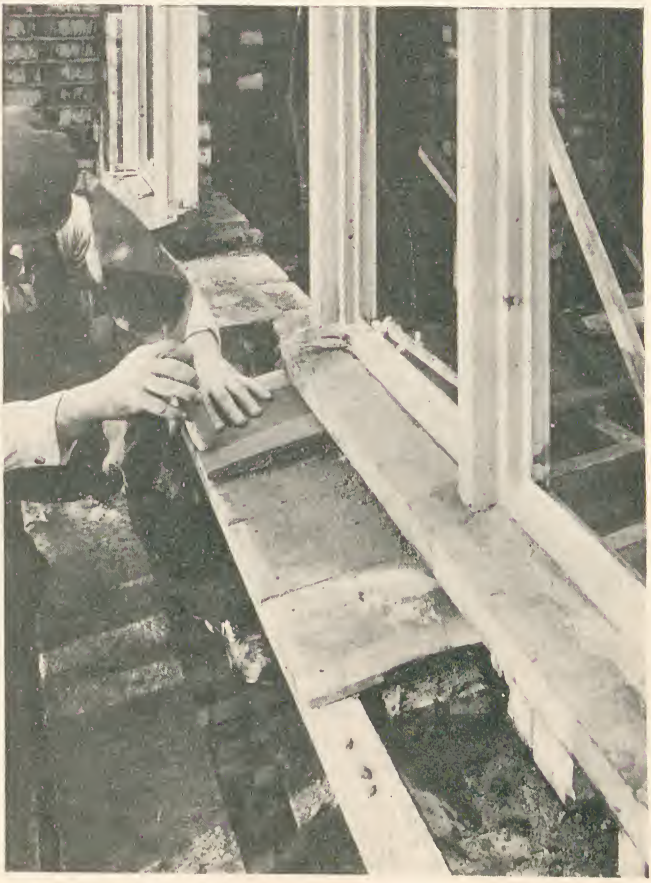


Fig. 14.—METHOD OF FIXING TILE CILLS

Tile cills must also be laid weathered. A batten is fixed along the front edge at a slightly lower level and the tiles packed at the back to give the slope.

Fixing Jamb Linings

When windows are built between brickwork it is seldom that jamb linings are used, the most satisfactory method being to plaster the reveals. If, however, they are required, in which case a soffit lining also would be required, it is essential that they should be tongued to the window board and the soffit, and further fixings made along the jamb by means of fixing bricks built in the brickwork at the specified intervals.

Fig. 15.—METHOD OF FIXING WINDOW BOARDS

Properly shaped wedges driven between joints provide a firm fixing. The last course of brickwork has been left down to facilitate the insertion of the tile cill. This should be properly filled in to help secure the wedges.

Fixing Soffit

As already suggested, no weight should be allowed to rest upon the head of the window ; the brickwork above may be carried on a concrete lintel. If this is the case, the soffit must be fixed to this lintel by means of very small plugs, but taking care when inserting these not to shatter the concrete. A very satisfactory way of fixing these is to place small dovetail fillets on the shuttering before the concrete is poured, and when the shuttering is struck these fillets are held in position by the concrete. Fig. 19 illustrates this method.

Another Method

A still further method of fixing the soffit, and for that matter the front edge of the jamb linings, is to fix a rough ground along the front edge. This ground serves a double purpose : first, to take the plaster ; secondly, as fixing for the soffit linings.

Architraves

Where linings are used architraves are generally adopted and the lining should be of sufficient thickness to allow the architraves to project

beyond the edge of the plaster, covering the edge of the lining to within about $\frac{3}{16}$ in. The architraves are fixed in all cases either to the rough grounds or to the fixing bricks. If grounds are omitted from the concrete lintels, then these latter must be plugged in the same manner as for the linings.

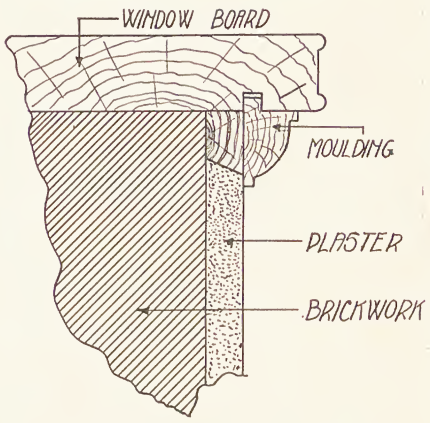


Fig. 16.—FIXING WINDOW BOARDS

A proper finish is obtained by fixing a ground as shown and then fixing a small moulding tongued into the window board.

Composite Type Windows

So far we have dealt with ordinary standard windows that do not call for the use of transomes or mullions. It is possible, however, to couple almost any of these types together in a horizontal or vertical manner by means of steel transomes or mullions provided for the purpose. When using these it is necessary to study the manufacturer's instructions regarding the extra height occasioned by their use, and this must be taken into consideration when calculating the size of the openings required in the brickwork.

Similarly, this same precaution is necessary when using the mullions, although in this instance no increase in width is necessary, as the mullion is taken up in the section of the frame. Some makers, however, do not adhere to type, and it is well to be on the safe side.

WINDOWS IN WOOD SURROUNDS

This method of fixing metal windows has many distinct advantages over the former, especially as the wood frames can now be obtained so cheaply from the manufacturers, with the various types of metal windows fitted complete ready for placing in the openings. Even so, if the wood surrounds have to be specially made the advantages still exist.

The first and main one is that the fixing or building in is rendered simple, as the window is treated as an ordinary cased frame or wood

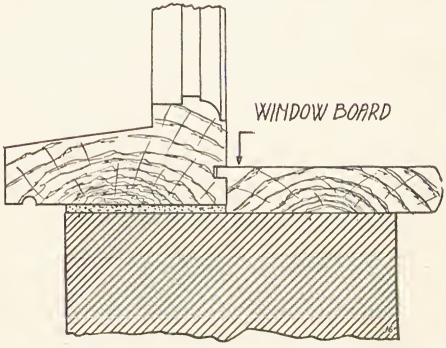


Fig. 17.—JOINT BETWEEN WOOD CILL AND WINDOW BOARD

The back edges of wood cills should be grooved to receive a tongue formed on the window board.

Fig. 18.—METHOD OF FIXING FOR WINDOW BOARDS
Showing breeze bricks, to which the board may be spiked.

casement; secondly, the internal finishings become a simple matter, and generally the whole appearance is enhanced by their use.

The narrow section windows are usually inserted in the wood frames, as the necessity for the wide flange to overcome rough-cast is non-existent, there being sufficient width on the wood surround to overcome this.

Construction of the Surround — Sizes and Timber

While no specific size of scantling is necessary for their construction, the best and most practical have been found to be as follows:—

Heads and posts out of 3½ in. by 2½ in.

Cills out of 6 in. by 3 in., or

Heads and posts out of 4 in. by 3 in.

Cills out of 6 in. by 3 in.

The cills, to give the best result, should be of oak, although deal is not prohibited, and is useful if a reduction in cost is desired.

Weathering

It is essential that the same attention be given to the weathering properties and groovings of these frames as was specified for the cills only. The posts are grooved on the back. This is known as a key groove, and when the frame is bedded against the jamb the cement is pressed hard into this groove and so makes a perfect joint.

The frames should also be grooved internally to receive the window boards and jamb and soffit linings.

Fixing the Metal Windows in Position

We have seen that in the construction of the frame a ½-in. rebate is allowed for the bedding of the steel section, but before this is done a putty or mastic bed should first be laid in position as shown in Fig. 22. The metal frame of the window is then pressed firmly in position as is shown in Fig. 23, after which the fixing screws may be inserted and the surplus of putty removed. This whole operation is a very important one, as unless it is carefully done it often causes leakage troubles.

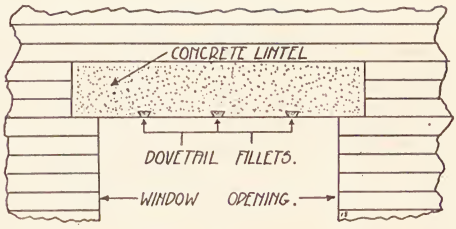


Fig. 19.—FIXING FOR SOFFIT LINING
Showing method of placing dovetail fillets in a concrete lintel to provide a fixing for the soffit lining.

There is no definite rule as to when the metal frames should be inserted, but if the wood frames are specially made and not supplied by the makers of the windows, it is better that they should be left until the completion of the erection of the superstructure, for the reason that the metal parts are likely to become damaged, in which case the whole window may have to be replaced.

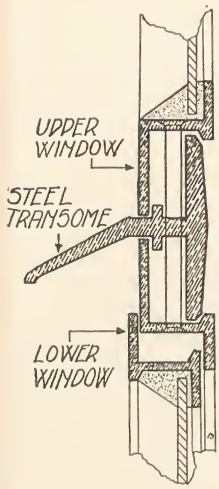


Fig. 20.—A PART SECTION THROUGH TWO STEEL WINDOWS

Over-all Sizes of Windows

If the windows are to be inserted after the brickwork is built, a little more care must be given to the question of setting out the openings where wood surrounds are used, as there are many ways of coupling the various types, using the two sizes of frames given above, that must inevitably dispense with a standard size of opening. For example, two windows 1 ft. 11 in. wide may be coupled together with an ordinary steel mullion and the whole inserted in a 4-in. by 3-in. frame, the steel mullion alone being sufficient to give an increased width. Or again a 4-in. by 3-in. frame giving an increased width over 3½ in. by 2½ in. Another method of coupling is by using a frame with a wood mullion, this giving a still further increase in the width. These same remarks also apply to the heights, as wood transomes can be used in the place of steel, which latter cause a reduction in

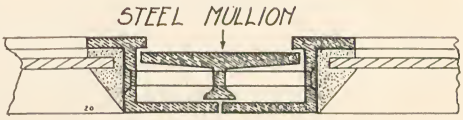


Fig. 21.—A SECTION THROUGH TWO STEEL WINDOWS FIXED SIDE BY SIDE BY MEANS OF A STEEL MULLION

Fig. 22.—FIXING METAL WINDOWS IN WOOD SURROUND

A putty bed must be formed to ensure a watertight joint between the wood and metal frames.

height as compared with those using wood transomes.

Figs. 24 and 25 show sections through a composite window using a wood mullion and transome respectively.

Methods of Building In

The practice here does not differ greatly from that of the ordinary steel frame, except that the wood frame complete with cill is placed in position in one operation. It will be noticed in Fig. 22 that the frames are supplied with their heads projecting beyond the posts, and although not illustrated the cills are extended in a similar manner. This is done in order that sufficient timber may be left on

Fig. 23.—METAL FRAME IN WOOD SURROUND

After the putty is inserted the metal frame is firmly pressed home and fixing-screws inserted.

the morticed members to allow for the tenons being properly wedged without splitting. While some of this timber must be cut away if the frames are to be inserted in face work, it must not all be cut, as otherwise the object of these "horns," as they are called, is nullified. To provide similar fixing to the jambs as is done by means of the lugs supplied with the metal frames, it is usual to fix at intervals strong hoop-iron ties, screwed to the back of the frame and extending into the brickwork.

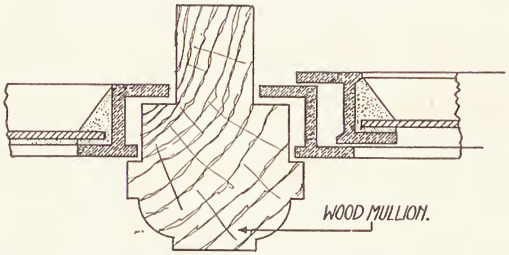


Fig. 24.—SECTION THROUGH A WOOD MULLION USED TO COUPLE THE STEEL WINDOWS

In the case of the cills there are several methods of treating them. For example, it is not necessary to cut these when building in, as the brickwork can be bedded direct on to the extension, thus forming a weight holding the frame in position. If, however, the frames are to be inserted in prepared openings with the cills projecting beyond the face of the brickwork, then a right-angled notch should be cut in each end in order that the front of the cill may run past the reveals. There are other ways of dealing with them, all depending upon the architectural effects used in the building, but the main point to remember is that these horns are left for a purpose.

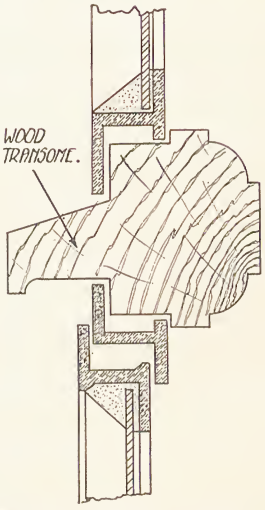


Fig. 25.—SECTION THROUGH WOOD TRANSOME

Note that the bottom front edge is treated in the same manner as the head of the frame and serves as a drip or throat.

Interior Finishings

These can be carried out in two or three different ways. Window boards may be composed of quarry tiles bedded to brickwork and the plaster continued into the reveals with a cover moulding covering the joint between the frame and plaster, or the openings may be fitted with window boards and linings.

Assuming the latter to be

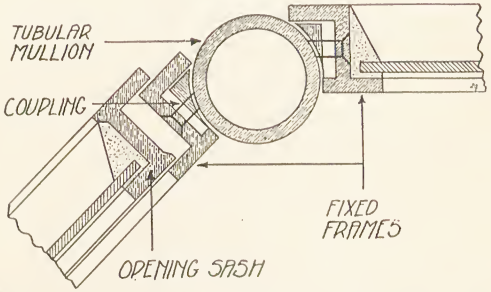


Fig. 26.—SECTION THROUGH TUBULAR STEEL MULLION

This type of mullion is used for coupling windows forming bays. The windows can be fitted at any angle desired.

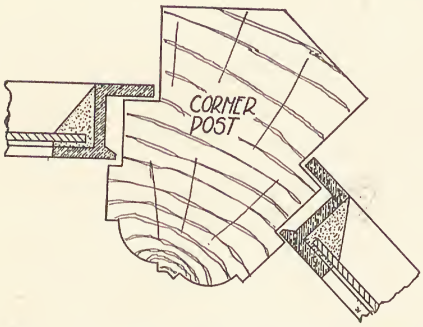


Fig. 27.—HOW THE FRAMES ARE MADE
Showing a solid corner post used for bay windows.

the case, the jamb linings should be housed to the window boards and tongued to the soffit lining, and all linings and window boards should be tongued to the frame. A practical method of fixing is to assemble the framing complete before placing it in the opening, when the tongues can be gently forced to the grooves in the frame.

It is sometimes, however, impossible to do this, as for example where the window board is made in one piece to extend across two or more windows. This latter is then first placed in position and the remaining linings properly fitted to their grooves.

BAY WINDOWS

Windows Without Wood Frames

Metal windows can be adapted to suit many types of bays by the use of mullions or corner posts. Fig. 26 shows the arrangement at one corner of a bay using a tubular mullion that is in common use, and these can be supplied to give varying angles. By coupling these mullions with the various types of standard windows any combination of bays can be set up; for example, three-sided, five-sided, or about semi-circular, and, in addition, can be used to form oriel windows.

Windows With Wood Frames

In this type we get several variations in the manner of assembly. Fig. 28 is a typical section through the posts of a pair of standard windows fitted to form the corner of a bay, and shows the insertion of a corner post to overcome the difficulty of filling the angle. By this method it is possible to couple any of the standard windows into the bay to give any desired result.

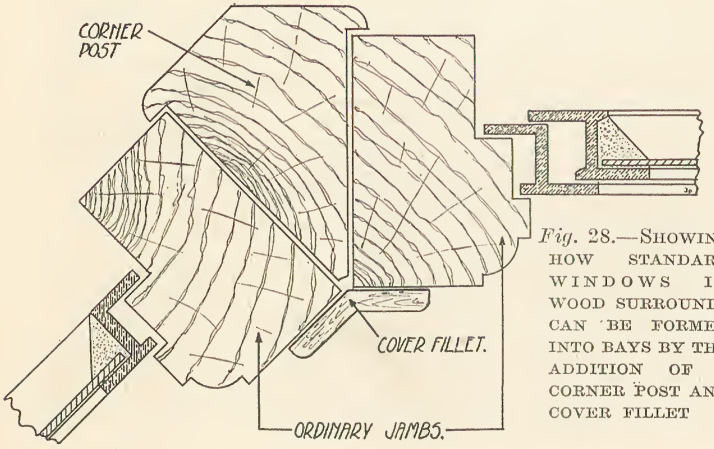


Fig. 28.—SHOWING HOW STANDARD WINDOWS IN WOOD SURROUNDS CAN BE FORMED INTO BAYS BY THE ADDITION OF A CORNER POST AND COVER FILLET

PLASTER AND ITS APPLICATION

THE art of the plasterer has descended to the craftsman of to-day through more than forty centuries, but in spite of its age, very few changes have taken place in plastering methods, or in the tools used by the operatives.

Plastering is a trade which has probably been affected less than any other by machinery, hand work being still the only method of application.

There have been some changes in plastering materials during the last twenty years, but these have come about very gradually ; the newer materials have not yet entirely displaced the older ones, and will probably not do so for many years to come.

Lime Plaster

For centuries, in this country, lime has been the principal material used in plasterwork, and most of the buildings erected up to the beginning of the present century were plastered with lime.

The condition of this old plasterwork at the present time speaks well for the durability of the materials used, and for the workmanship exercised in their application.

How Limestone Is Prepared for Use

Limestone, from which plasterers' lime is made, is quarried in various parts of the British Isles, and is prepared for use by calcining in kilns, during which process, water and carbon dioxide are expelled from the rock.

After calcination, the quicklime, as it is now called, is slaked in a large tub or cistern to prepare it for use in making mortar.

Where the work is of sufficient magnitude, a large square pit is prepared either by digging in the ground, or by building four sides with planks to form a reservoir.

The cistern or lime-box is mounted at one end of the pit and has a sluice covered with a sieve or fine grating at one of its ends ; the box is so placed as to have a slope towards the pit.

Water is run into the box until it is about half full, then the quicklime is placed in the water until the whole of the box is covered, care being taken to keep the lime under water.

As soon as the pieces of lime come in contact with the water, they commence to absorb it very quickly and with great energy ; considerable heat is generated, and violent boiling takes place.

When boiling has ceased, the lime has changed from a stone-like

form to a thick paste ; this is stirred vigorously with a paddle to ensure thorough mixing with the water, the sluice in the box is opened, and the liquid falls into the large pit, where it remains to cool off, and stiffen into what is known as lime putty.

This should stand in the pit for at least a month to ensure that all the lime is thoroughly slaked ; should any unslaked particles be allowed to enter the mortar, they would cause trouble by slowly expanding and producing blisters on the face of the finished plasterwork. After slaking, the lime has increased to three or four times its original bulk.

When matured, the lime putty is taken from the pit, and mixed with sand in various proportions according to the purpose for which the mortar is intended.

Lime for Lath Ceilings

If for lath ceilings, one part of lime would be added to two parts of sand, and there would be incorporated in the mix a quantity of ox or goat's hair to act as a binder or reinforcement.

Lime for Brick Walls

If for application to brick walls, three or four parts of sand would be added to one part of lime with a smaller quantity of hair than for lath work.

These mortars are usually mixed in large quantities and allowed to stand for some time before use : this has the effect of improving their working qualities.

Sand is used to increase the bulk and to prevent shrinkage ; lime cannot be used alone, because whilst in a plastic state it contains a large quantity of water, which evaporates during drying, causing considerable reduction in bulk ; and if used as a plaster by itself, would shrink and crack.

Hydraulic Limes

Lime is rarely found in a pure state, and the degree of impurity varies in different quarries ; some of these impurities, such as clay, have a beneficial effect on the lime, imparting to it a quality known as hydraulicity, which means the power of setting or hardening in the presence of moisture.

These hydraulic limes, as they are called, are not favoured by the plasterer, because although they attain great strength, their working qualities are inferior to the rich or fat limes, which also have a greater capacity for carrying sand.

The Best Lime for Plastering Purposes

The ideal lime, therefore, for plastering purposes is one having the highest percentage of calcium carbonate, lime of this kind is found in Derbyshire, where the limestone is the purest in the country.

Fig. 1.—RUNNING LIME (1)

The lime has been slaked in the large tubs and is being stirred with a paddle before passing it through the sieve into the pit.

Fig. 2.—RUNNING LIME (2)

After thoroughly stirring with the paddle the liquid lime is ladled through the sieve to remove any coarse particles which remain after slaking.

Fig. 3.—MAKING UP " COARSE STUFF " (1)
Adding lime " putty " to sand.

Fig. 4.—MAKING UP " COARSE STUFF " (2)
Mixing with rake or " larry."

Sand for Plastering

Sand for plastering should be clean and sharp or gritty, angular in grain, and free from clay, vegetable matter, and salts.

Pit sand, or river sand if obtained from fresh-water streams, is best, but sand from the sea shore can be used if washed free from salt.

Laths for Ceiling and Partition Work

Laths for ceiling and partition work are an important item in plasterwork, as upon their quality depend the strength and durability of the plaster they support.

Strips of oak were used in the early days, but these gave way to laths made from Baltic fir, which were split by hand from logs sawn to suitable lengths.

These split or riven laths were cleft in the direction of the grain of the wood, the fibres running the full length of each lath, consequently they did not twist or buckle when wet plaster was applied.

Lath splitting was a separate trade and considerable skill was necessary to split the laths to a uniform width and thickness.

Machine-sawn Laths

Hand-riven laths have given way to a large extent to machine-sawn laths which, although more regular in width and thickness, and easier to fix than the older variety, are not so reliable, many bundles containing knotty and cross-grained pieces which are liable to twist and buckle when wet, causing cracking and bulging of the plasterwork.

Sizes of Laths

Laths, whether split or sawn, are made in three grades of strength : single lath which is $\frac{3}{16}$ in. thick, lath and half which is a rather full $\frac{1}{4}$ in. thick, and double lath which approximates to $\frac{3}{8}$ in. thickness.

Lath and half strength is commonly used in good work.

The nails used in fixing laths are 1 in. wire with round heads, these are sometimes galvanised, but plain wire nails are generally used.

Metal Lathing

There are several brands of metal lathing on the market for use as substitutes for wood laths where ceilings are required to be fireproof ; these are usually supplied in sheets measuring 10 ft. by 2 ft. and are fixed to joists with galvanised staples.

The materials used in lime plastering having been described, the application of these materials to the work may now be discussed.

Preparing a Ceiling for Plastering

To begin with the ceiling : the laths are nailed across the joists with at least one-quarter of an inch space between them, one nail being driven

through the lath at each joist. At intervals of 2 ft. 6 in., the lather "breaks joint," which means that instead of nailing his laths to joists 1, 2, 3, 4, he nails them to joists 2, 3, 4, 5, thus jumping the joint sidewise. After proceeding for another 2 ft. 6 in., he goes back and continues his next stretch on 1, 2, 3, 4, and so on until the ceiling is covered.

The object of the broken or jumped joint is to strengthen the ceiling, and to prevent cracks, due to possible movement of timber, from extending farther than each 2 ft. 6 in. section.

Where the ends of laths meet on a joist they should be kept $\frac{1}{4}$ in. apart and separately nailed.

The Rendering or First Coat of Plaster

When lathing is completed, the next operation is the rendering or first coat of plaster; good plasterwork should be executed in three coats, so that the shrinkage which takes place in all lime plaster is reduced to a minimum.

The rendering coat, composed of two parts sand and one part lime, with well-beaten hair added in the proportion of 9 lb. per cubic yard, is laid evenly over the laths, pressed firmly up between the spaces so as to "key" itself firmly, and after being straightened with a rule, is scratched all over the surface with a tool made of several pieces of lath cut to sharp points and fastened together in the form of a large fork.

This is to provide a "key" for the coats which are to follow; the ceiling is then allowed to stand until the plaster has become completely dry and hard.

This may take from two to three weeks according to weather conditions.

First Coat of Plaster for Walls

In the meantime the walls receive their first coat of plaster, which should be composed of three parts of sand to one part of lime with about half the quantity of hair per cubic yard given for rendering on lath; this coat is similarly roughened and left to dry out.

The porosity of the brickwork causes the plaster to dry more quickly than that which is applied to the lathwork, consequently the second coat may follow in a few days' time.

The Second or Floating Coat for Walls

The proportions should be the same as for the rendering, and the second or floating coat is laid and ruled to a level surface; as it dries, it is scoured with a tool called a hand float (see sketches) to fill up any small hollows which may have escaped the floating rule, and the surface is roughened by scratching with a wire scratch or by small nails projecting from the sole of the hand float. The walls are then ready for the setting or finishing coat, which is not applied until after the ceilings are completed.

Fig. 5.—LATHING

The foregoing operations are usually carried out throughout the whole of a building, or at least a considerable portion of it, so that by the time each coat has been completed, the rooms or sections first covered have become dry enough to receive the following coats.

The Cause of Cracks

It is not safe to apply a second coat before the first one has dried, because of the shrinkage previously mentioned. If one coat follows the other too quickly, cracks will appear and the work will be unsound.

Second Coat on Ceilings

The second coat on lathwork is also called the floating coat, and like the second coat on walls is composed of three parts of sand to one of lime with 4 lb. of hair to the cubic yard.

This coat is straightened by ruling as in wall work and scratched in the same manner to receive the setting coat.

How to Deal with Angles

Where there are salient angles, such as occur at window reveals or the sides of chimney breasts, etc., Portland cement and sand are applied in narrow bands each side of the angle to take the place of the lime plaster, which is not hard enough to withstand any hard knocks or wear and tear such as these positions receive.

Fig. 6.—APPLYING THE RENDERING OR FIRST COAT OF PLASTER TO THE LATHS

These cement angles are worked flush with the lime floating coat, and when set hard are finished with Keene's or Parian cement to a width of 2 in. each side, the finishing cement being laid on to a thickness of $\frac{1}{8}$ in. and cut to a straight line ; this band of hard material protects the angle, and forms a thickness guide for the plasterer when applying the setting coat.

" Cornicing " and Moulding

If moulded cornices are to be run, this operation follows on after the completion of the floating coats and the formation of the angles.

" Cornicing " belongs to the more interesting sections of the plasterers' craft, and although the mouldings of the present day are less ornate than those of former times, the principle and operation are the same.

The " Running Mould "

A " running mould " is made by cutting a profile in thin sheet iron to the design given in the architect's drawing and mounting this profile on a wooden " stock " or " horse," which is usually a piece of 1-in. timber cut to the same profile but allowing the iron to project $\frac{1}{8}$ in. beyond the wood.

This stock is in turn mounted on a " slipper," the length of which should be at least equal to the height of the stock.

Fig. 7.—MIXING LIME PUTTY WITH PLASTER OF PARIS FOR THE FINAL COAT OF PLASTER

Fig. 8.—APPLYING THE FINAL COAT OF PLASTER TO CEILINGS

" Sweetening " the Rough Floating Coats

The depth and projection of the proposed moulding having been marked out in the angle formed by wall and ceiling, the plasterer proceeds to " sweeten " the rough floating coats, by applying a thin coat of setting plaster mixed with plaster of paris in a narrow band along wall and ceiling to provide a smooth surface for the mould to run upon.

Again the projection and depth are marked out, and with a line rubbed in charcoal the plasterer strikes lines on wall and ceiling which determine the position of the cornice.

Strips of wood 2 in. by $\frac{3}{8}$ in. are then nailed along the wall line and fastened securely in position by placing small blobs of plaster at intervals, which when set hard hold the strips or " running rules " firmly.

How Heavy Mouldings Are Formed

Some mouldings are heavy in character and require a large quantity of material to form them ; in these cases they require to be cored out in gauged coarse stuff, or in other words lime and sand mortar mixed with plaster of paris.

To carry out this operation the running mould, previously described, is fitted with a profile cut out of sheet iron, similar in details to the one already fitted, but projecting beyond it $\frac{1}{8}$ in.

This is called a muffler, or muffling-iron, and its purpose is to enable the plasterer to run his moulding roughly in the coarse stuff, keeping it $\frac{1}{8}$ in. smaller every way than the finished cornice.

Preparation of Coarse Stuff for Coring Out

Having fixed all the running rules or strips, and muffled the running mould, the plasterer mixes a batch of coarse stuff for coring out, by forming a ring on the mortar board with as much coarse stuff as can conveniently be used, pouring in water from a pail so that the ring of stuff forms a small pit containing it. Dry plaster of paris is then sprinkled into the water until the whole of it has been covered ; this is allowed to settle for a few seconds, then plaster and coarse stuff are thoroughly mixed up, several times' turning over being necessary. Equal parts of plaster and coarse stuff should be used for this.

Forming the Moulding

The mixture is then plastered roughly in the angle where the moulding is to be formed, and crudely shaped by the trowel.

Taking the running mould in his right hand, the plasterer, resting the lower part on the running rule, and pressing the upper part hard against the ceiling, pushes the mould from right to left along the rule, the iron profile of the mould cutting or scraping away the surplus material.

This is caught by the plasterer on the " hawk," which is held in the left hand.

Parts which were not filled out by the first application of the coarse stuff are then attended to, and the operation repeated until the work is sufficiently well shaped to take the thin finishing coating.

The muffle iron is then removed, and the mould cleaned to remove all trace of the rough coarse stuff, which might deface the finished work if allowed to remain.

If the mould is now run along the rules as before, it will be seen that the iron profile misses the cored-out members by $\frac{1}{8}$ in. all over, which is the thickness allowed for the finishing coat of fine stuff.

The Finishing Coat for Moulding

A mixture of fine lime putty and plaster of paris is prepared on the board in the same manner as the coarse stuff, the proportions of plaster and lime putty being equal, and after thorough mixing, is used to coat the roughly formed moulding all over.

The mould is again made to travel along the running rule, taking off the surplus plaster, and eventually leaving the finished moulding true to the pattern cut from the drawing.

In the corners, or where two lengths of moulding meet, the length of the slipper prevents the profile from running close in, and it is necessary to work these short lengths in by hand. The junction of two lengths of moulding is called a mitre, and the operation of forming it is called mitring, a process requiring considerable skill of both hand and eye.

In many cases, the work of cornicing is given to special men whose superior workmanship makes them more capable of this kind of work than others less skilful.

Final Coat for Ceilings

After cornicing is completed, the running rules are removed and cleaned to be used again, and the ceiling is prepared to receive its finishing coat of fine stuff.

Preparation consists in scraping off any splashes of material left from the cornicing and laying on a thin coat of lime putty mixed strongly with plaster of paris ; this is first applied all over with a steel trowel, then " closed " or " tightened " with another coat applied with a wooden float, which in turn is followed by a further very thin coat with the trowel.

The " suction " or absorption of the under coat, together with the setting of the plaster, has by this time hardened the finishing coat sufficiently to enable the plasterers to trowel it to a smooth, hard face.

Final Coat for Walls

The walls are finished in the same manner, although in some cases, on wall finishing, the mixing of plaster of paris with the setting coat is dispensed with, and a finish of $1\frac{1}{2}$ parts sand and 1 part lime is used ; in

Fig. 10.—APPLYING THE FINAL COAT OF PLASTER

Fig. 9.—APPLYING THE RENDERING COAT

this case the walls are covered with a thin coating, and allowed to become nearly dry, then followed by a further coat or coats to tighten or close up the surface, trowelling off as for ceilings.

Bevelled rules or "feather-edges" are used to straighten out the internal angles when applying the first part of the setting coat.

The foregoing describes the plastering, in lime materials, of an average "good job," such as a reasonably well-built house or public building, and if carried out as stated, a sound and workmanlike job will result.

Fig. 11.—FINISHING THE INTERNAL ANGLES

Importance of Time in Plastering

The most important thing in lime plastering, apart from good materials, is abundance of time.

Time is necessary to allow each coat of plaster to dry out, before another coat is applied.

Lime hardens very slowly, by a two-fold process—evaporation and carbonation.

Evaporation relieves the lime of the surplus water added to it at the time of slaking, and carbonation occurs by the absorption of carbon dioxide from the atmosphere.

There are no means of hastening this process without adversely affecting the quality of the finished work, and in all lime plastering, the more the natural processes are allowed to operate, the better the result.

Methods Employed to Hasten the Hardening Process

For many years it was the custom, when work had to be hurried, to mix plaster of paris with the coarse undercoating in order to speed up the hardening process and allow work to proceed without waiting for natural drying out to take place.

This was not always successful and much of this kind of work suffered from cracking and other weakness after the work became dry.

It has to be realised that when plaster of paris or any other setting agent is added to lime, it is only that agent which actually sets, not the mass of lime with which it is mixed, and that the moisture contained in the mass has still to be evaporated; also, until evaporation takes place the lime cannot carbonate.

The hardening of a mixture such as this is due to the power of the setting agent to hold or support—by a network of crystals interlacing the mass—the bulk of material with which it is mixed, but the hardening is not the same as that which comes from natural drying out.

Patent Plasters

During the last quarter of a century, there have been many patent plasters introduced with the object of providing materials which will allow work to proceed rapidly.

These are made from gypsum, or calcium sulphate, and can be divided into two classes, the hemi-hydrate or plaster of paris type, and the anhydrous or Keene's cement type.

The Hemi-hydrate Plasters

Plaster of paris is calcium sulphate which has been deprived of part of its water of hydration by heat, and converted into a hydrate. In this condition, if fresh water be offered to it, it will combine with a quantity equal to that lost in burning, and will set into a hard mass. This setting is due to re-hydration, whereby gypsum is re-formed. The hemi-hydrate plasters are made on this principle.

The Anhydrous Plasters

If calcination is prolonged until all the water of hydration is expelled, the gypsum becomes " dead burnt " and will not set rapidly like plaster of paris, but will harden very slowly, re-crystallisation being greatly delayed by dead burning. It will, however, attain great hardness and strength, eventually.

To make this material workable, an accelerator is added, such as alum, which has the effect of producing an initial set or hardening.

This is the principle upon which the accelerated anhydrous materials, such as Keene's cement, are made.

Anhydrite Plaster

Plaster is also made from the mineral anhydrite, and this has the same properties as the artificially produced anhydrous cements.

Using the Hemi-hydrate Plasters

The hemi-hydrate plasters are made in two grades: coarse, for the backing coats, and fine, for the setting or finishing coat. To make them workable, the natural set is controlled by adding a retarder, which slows down the setting time in order that reasonable batches of material may be prepared and used before the set takes place.

Only Two Coats Required

The work is carried out in two coats instead of three, as in lime plastering, and, as the backing coat sets hard in a few hours, the finish can be applied very soon after the work has commenced.

The Backing Coats

For the backing coats two or three parts of sand are added to one part of the plaster, which is first dry-mixed, then water is added to bring the mix to a plastic condition; application is similar to that employed in lime work.

For ceilings and partitions which are lathed, hair is added to the plaster during manufacture, but for use on brick walls unhaired plaster is used.

The Finishing Plaster

The finishing plaster is mixed in a pail to the consistency of thick cream and used in the same manner as lime setting-stuff.

Care must be taken to keep tools and utensils clean and to use only clean water for mixing.

Water in which tools, etc., are washed contains particles of set material, which, if allowed to enter the mix, cause quickening of the set.

Partially or wholly set plaster from a previous mix will have the same effect, consequently each batch should be used up completely before a new one is prepared.

Properly handled, the retarded hemi-hydrated plasters possess certain advantages over lime plasters, the principal one being the saving of time in completing work. A job may be commenced one day and finished the next.

There is also freedom from decorating difficulties; these plasters do not affect painting materials, which can safely be applied as soon as the work is completed, and reasonably dry.

Using the Accelerated Anhydrous Plasters

The accelerated anhydrous plasters, or gypsum cements, are used in practically the same manner as the hemi-hydrates, but they are not

Methods Employed to Hasten the Hardening Process

For many years it was the custom, when work had to be hurried, to mix plaster of paris with the coarse undercoating in order to speed up the hardening process and allow work to proceed without waiting for natural drying out to take place.

This was not always successful and much of this kind of work suffered from cracking and other weakness after the work became dry.

It has to be realised that when plaster of paris or any other setting agent is added to lime, it is only that agent which actually sets, not the mass of lime with which it is mixed, and that the moisture contained in the mass has still to be evaporated; also, until evaporation takes place the lime cannot carbonate.

The hardening of a mixture such as this is due to the power of the setting agent to hold or support—by a network of crystals interlacing the mass—the bulk of material with which it is mixed, but the hardening is not the same as that which comes from natural drying out.

Patent Plasters

During the last quarter of a century, there have been many patent plasters introduced with the object of providing materials which will allow work to proceed rapidly.

These are made from gypsum, or calcium sulphate, and can be divided into two classes, the hemi-hydrate or plaster of paris type, and the anhydrous or Keene's cement type.

The Hemi-hydrate Plasters

Plaster of paris is calcium sulphate which has been deprived of part of its water of hydration by heat, and converted into a hydrate. In this condition, if fresh water be offered to it, it will combine with a quantity equal to that lost in burning, and will set into a hard mass. This setting is due to re-hydration, whereby gypsum is re-formed. The hemi-hydrate plasters are made on this principle.

The Anhydrous Plasters

If calcination is prolonged until all the water of hydration is expelled the gypsum becomes " dead burnt " and will not set rapidly like plaster of paris, but will harden very slowly, re-crystallisation being greatly delayed by dead burning. It will, however, attain great hardness and strength, eventually.

To make this material workable, an accelerator is added, such as alum, which has the effect of producing an initial set or hardening.

This is the principle upon which the accelerated anhydrous materials such as Keene's cement, are made.

Anhydrite Plaster

Plaster is also made from the mineral anhydrite, and this has the same properties as the artificially produced anhydrous cements.

Using the Hemi-hydrate Plasters

The hemi-hydrate plasters are made in two grades: coarse, for the backing coats, and fine, for the setting or finishing coat. To make them workable, the natural set is controlled by adding a retarder, which slows down the setting time in order that reasonable batches of material may be prepared and used before the set takes place.

Only Two Coats Required

The work is carried out in two coats instead of three, as in lime plastering, and, as the backing coat sets hard in a few hours, the finish can be applied very soon after the work has commenced.

The Backing Coats

For the backing coats two or three parts of sand are added to one part of the plaster, which is first dry-mixed, then water is added to bring the mix to a plastic condition; application is similar to that employed in lime work.

For ceilings and partitions which are lathed, hair is added to the plaster during manufacture, but for use on brick walls unhaired plaster is used.

The Finishing Plaster

The finishing plaster is mixed in a pail to the consistency of thick cream and used in the same manner as lime setting-stuff.

Care must be taken to keep tools and utensils clean and to use only clean water for mixing.

Water in which tools, etc., are washed contains particles of set material, which, if allowed to enter the mix, cause quickening of the set.

Partially or wholly set plaster from a previous mix will have the same effect, consequently each batch should be used up completely before a new one is prepared.

Properly handled, the retarded hemi-hydrated plasters possess certain advantages over lime plasters, the principal one being the saving of time in completing work. A job may be commenced one day and finished the next.

There is also freedom from decorating difficulties; these plasters do not affect painting materials, which can safely be applied as soon as the work is completed, and reasonably dry.

Using the Accelerated Anhydrous Plasters

The accelerated anhydrous plasters, or gypsum cements, are used in practically the same manner as the hemi-hydrates, but they are not

nearly so satisfactory as these when used as backing coats. Although they attain great strength when used in a pure state, they have very low sand-carrying power, and are inferior to the hemi-hydrates in this respect.

Best Employed as Finishing Coats

They are, therefore, best employed as finishing coats on harder backings such as Portland cement and sand or, alternatively, lime and sand mixed with Portland cement. Their hardness and density make them suitable for work where excessive wear and tear are to be expected, or where great cleanliness is desired, such as in hospital wards.

The Plaster Board or Gypsum Lath—

A further departure from ancient methods is to be found in the growing use of the plaster board, or gypsum lath, in place of wooden laths for ceilings and partitions.

These boards consist of a gypsum plaster core with a covering of specially made fibrous paper, and are made in sheets $\frac{3}{8}$ in. thick, and slightly less than a square yard in area.

—and Their Advantages

Their chief advantage is that when fixed they provide a sound plaster base which has no shrinkage and therefore does not crack.

Another point in their favour is that in one operation two stages in the construction of a ceiling are completed, viz. lath and first coat of plaster.

Covering the Joints

After the boards are fixed to the joists, the joints are covered with a band of scrim or coarse canvas 4 in. wide, plastered tightly down to the boards with some of the finishing plaster.

When this has set hard, the whole area is finished with a coat of hemi-hydrate plaster of the finishing grade, and the work is complete.

An alternative and stronger process is to render the boards with a coat composed of two parts of sand to one part of backing grade plaster, afterwards finishing with a thin coat of the finish plaster.

Only Hemi-hydrates Can Be Used with Plaster Boards

Lime plaster is not suitable for covering gypsum plaster boards, neither are the accelerated anhydrous plasters or cements: their nature does not allow them to form a bond with the paper covering of the boards. The only suitable materials are the hemi-hydrates, which unite firmly with the surface, because in setting, their crystals penetrate the pores of the fibrous paper and there securely lock themselves.

BENDING LIGHT-GAUGE COPPER TUBING

USING THE "HILMOR" PORTABLE BENDING OUTFIT

IN view of the rapidly increasing popularity of British standard light-gauge copper tubing for gas, water, and central-heating installations, the following notes on the use of the "Hilmor" portable bending outfit, which may be used in premises without causing any damage, will be found of interest.

How to Operate the Machine

The machine should be used in the following manner :—

(1) Open the stand to its full extent, and insert the fixing-pin.

(2) Insert the tube into the groove of the semicircular former and push it under the groove of the stop.

(3) Insert the guide over the tube, with the knife edge into the former, and proceed to bend as follows :—

(4) Place one foot on the stand of the machine.

(5) Grip the handle firmly with both hands and pull round evenly, as shown in Fig. 1.

On no account must the tube itself be gripped or assisted in the course of bending, otherwise ripples will form and the back of the bend will become flat. Let the lever do the bending. If you grip the lever with both hands you will not be tempted to touch the tube.

Short ends, offsets, etc., should be bent by using the lever in a downward direction, as shown in Fig. 1.

Bending Long Lengths of Tubing

Fig. 2 shows the method of bending long ends or bending in the middle of long lengths of tubing.

First bring the lever down under the machine and place the stop upside down in a hole in the bottom of the stop bar (Fig. 5). Place the tube in the underside of the former and push it over the stop (C). Next place the guide in position and pull the lever upwards. The foot should be placed on the cross-member of the front legs of the stand to keep the machine rigid while bending.

The guide is long enough to produce a 90° bend. If the bend is to be

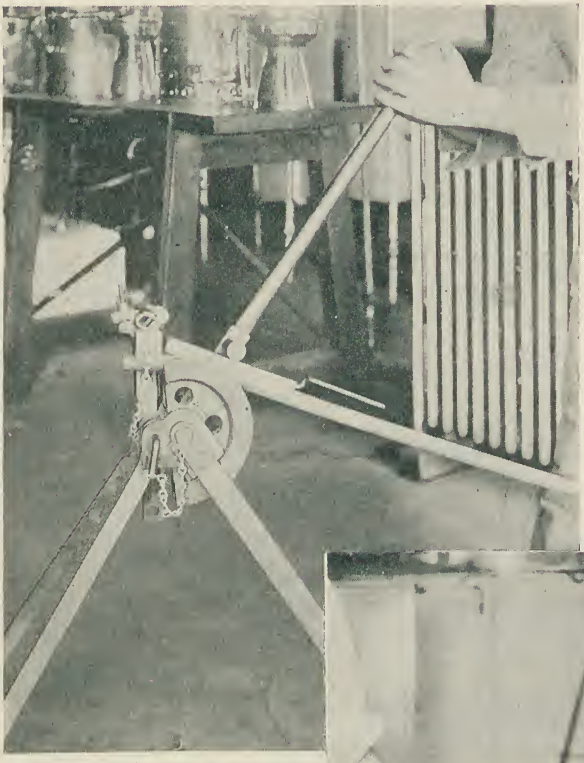


Fig. 1 *(above).* — BENDING SHORT-END LENGTH OF COPPER TUBING

Note that bending is being done downwards from the top of the former.

Fig. 2 *(right).*—BENDING A LONG-END LENGTH OF LIGHT-GAUGE COPPER TUBING

Note that the work is being done upwards from the underside of the former.

ticular size of tubes (see Fig. 8).

This is to facilitate bending to given measurements. Outside or inside measurements can be accurately obtained if the following instructions are carried out.

greater than this, draw the guide forward and proceed with the bending. It is most important to see that the roller does not run off the end of the guide.

How to Use the Machine to Bend to Measurements

It will be noted that the formers on all "Hilmor" machines are machined to the exact depth and diameter of the par-

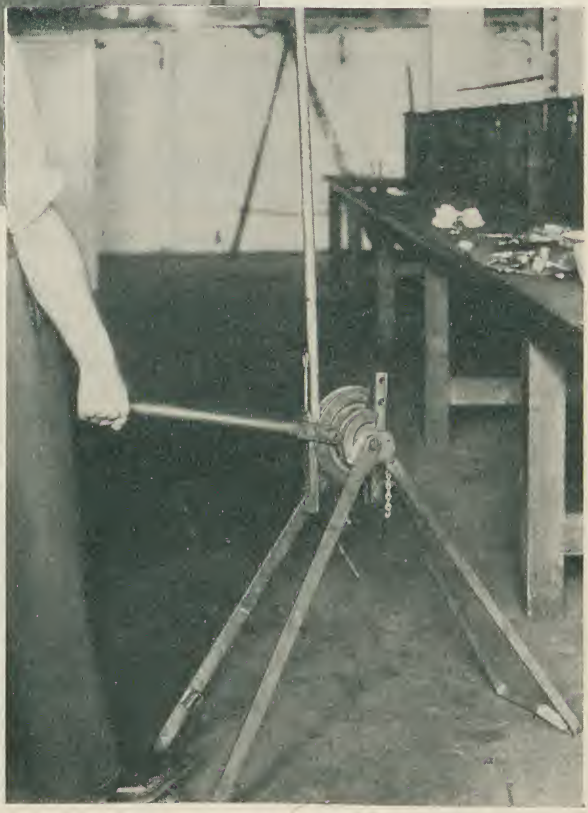


Fig. 3.—MAKING A SET IN COPPER TUBE, USING THE "HILMOR" BENDER
Note the bender used above is of the type which is clamped to the bench.

Fig. 4.—MAKING AN OFFSET (1)
First mark off the tube to the centre of the first set, as shown at (A).

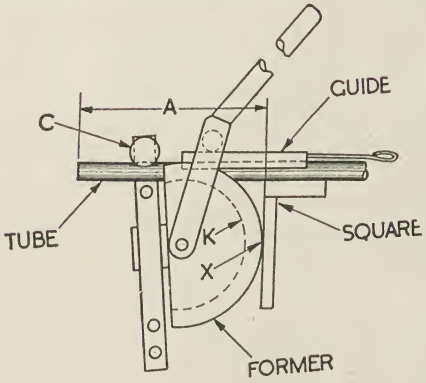


Fig. 5.—MAKING AN OFFSET (2)
Next, place tube in bender as shown above. Note method of determining position of (A) with square.

Fig. 6.—MAKING AN OFFSET (3)
Now measure the required offset.

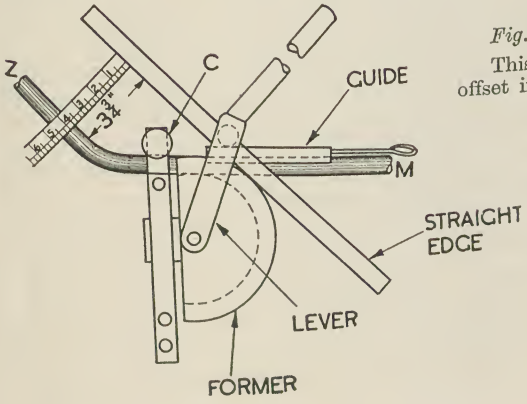


Fig. 7 (*left*).—MAKING AN OFFSET (4)
This shows how to obtain the desired offset in the machine.

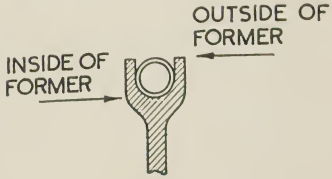


Fig. 8.—SHOWING HOW THE FORMER EXACTLY FITS THE TUBING

To Bend to Outside Measurements

Mark the tube, as shown in Fig. 4, to the measurement required at (A). Insert the measured end in the machine so that it rests against the stop (C) and push the tube right into the former. Place a square against the mark on the tube and slide the tube along until the square touches the outside edge of the former (X) (Fig. 5). Now proceed to bend.

To Bend to Inside Measurements

Mark the tube as above, but instead of the square and mark touching the outside of the former, slide the tube farther through the machine until the square touches the root of the former (K) (Fig. 5). The same principle applies in measuring from bend to bend, i.e. from the outside of one bend to the outside of another.

How to Make Offsets with the Machine

First determine the bevel required for the first bend, Fig. 6 (45° is the normal). After bending, place the tube in the machine as shown in Fig. 7, resting it against stop (C) and pushing it into the former. Place the straight-edge (or a piece of straight material) against the outside edge of the former and parallel with the tube as at (Z).

Now measure the desired set; it should be noted that the set will increase by pushing the tube forward, and decrease by pulling the tube towards you. When the correct measurement is obtained, bend in the usual manner until the end of the tube (M) is parallel with (Z).

Bending a Series of Offsets

If a series of offsets is required, bend all the tubes to the one level, place one tube in the machine to the correct measurement, and mark the tube at the spot where it touches the stop. Use this one as a template and mark the remaining tubes. No straight-edge or rule is required once this template is produced.

The "Hilmor" bender is also available for workshop use, where it can be rigidly attached to a bench. This bench type is shown in use in Fig. 3, where it will be seen that the right hand of the operator is being used to pull the lever round. The left hand, although it is grasping the tube, is not pulling it, but rigidly supporting it.

Make a special point of keeping the guides and formers scrupulously clean. If dirty, they will score the tubing when bending it.

WALL BOARD ERECTION

IT is proposed in this article to give practical fixing directions for the three different kinds of wall boards now in extensive use.

(1) The thin fibre wall board or plywood wall board usually about $\frac{3}{16}$ in. thick.

(2) The thick insulating wall board usually about $\frac{1}{2}$ in. thick.

(3) The plaster wall board usually about $\frac{3}{8}$ in. thick.

THIN FIBRE OR PLYWOOD WALL BOARDS ($\frac{3}{16}$ in.)

Arranging the Panelling

In laying out the panelling keep in mind the following general points, which apply to all classes of work.

Make the ceiling plan symmetrical. If the standard panel widths interfere with the symmetry of design, trim the panels to a uniform width.

If the Wall is Broken by a Door or Window

Use a uniform panel design on the walls. Where the wall is broken by a door or window, each window or door should be considered as running the full height of the room. This divides the wall into several sections of different widths.

The Cover Fillets

While the style of the wood cover fillets is often dependent on the panel design selected, on the height of the room, and on the purpose to which the room is put, usually the plain, flat strip may be used ; or any of the more elaborate types of mouldings. In this way, the selection of wood cover fillets becomes the largest determining factor in the cost of the work.

Don't Use Flimsy Strips

The cover fillets are an integral part of the room design, and care in selecting and finishing them will be amply repaid in the superior appearance of the finished job. Only thoroughly seasoned timber should be used. If it is to be stained, select a wood with a grain that will show to good advantage. The surface should be perfectly smooth in every case.

Above all things, avoid using flimsy strips. Nothing less than $\frac{3}{8}$ in. by $2\frac{1}{2}$ in. should be used.

The Secret of Successful Work

The real secret of successful designing is to divide all of these sections uniformly. If all the walls are uniformly panelled, the effect will be entirely pleasing. It is essential to make the panel widths of the different sections as nearly as possible the same.

When panel strips extend above a door or window, it is good practice to have them break a little in from the top corners of the casing. Horizontal strips wider than the vertical wall battens give a better effect.

Do not be afraid of having too many panels. It is the use of panels that gives the most modern and attractive decorative effects.

Take into consideration the use to which the room is to be put, and the need of getting variety throughout the house, when selecting the panel arrangement. The height of the room should also be considered.

Then, of course, the requirements of cost will affect the panel design. The simpler the arrangement the less work involved. Some types of panelling require the use of more elaborate and costly mouldings to bring out their greatest possible effectiveness.

PREPARING THE WALL

Nailing Surfaces Required

In new frame construction the studding and joists furnish a nailing surface for centres and side edges of the wall board panels.

A firm surface for nailing the ends of each panel should also be provided. You can do this by nailing odd pieces of wood such as short lengths of 2 in. by 2 in. or 2 in. by 4 in. between the studs and the joists.

" Headers " for Skirting, Chair Rails and Plate Rails

It is also necessary to place these " headers " behind the top of the skirting, and back of the chair rails, plate rails, picture mouldings, or other wood cover fillets.

Studding or joists should not be spaced at greater distances than 16 in. or 18 in. centre to centre.

Special " Headers " in Kitchen and Bathroom

In kitchens and bathrooms, or wherever such appliances as sinks, washbasins and cabinets are to be used, additional " headers " will be required so that the fixtures may be securely fastened to the wall.

Dealing with Brick and Concrete Walls

Brick or concrete walls must be battened. That is, strips of wood called " grounds " must be fastened to the masonry to provide a nailing surface for all panel centres and edges. These strips should be of uniform thickness and not less than $\frac{7}{8}$ in. by $2\frac{3}{4}$ in. in section. It is sometimes possible to nail these strips to soft brick walls, but usually it is necessary to use wooden plugs or screws in fastening the strips.

A Precaution Against Damp

Where wall board is used near damp outside walls it is well to cover the back of the board with waterproof varnish. It is also desirable to treat the outside walls with a waterproofing compound.

Remodelling Work

In remodelling work, wall board may be applied directly over the old wall and ceiling material.

Covering Cracked Ceilings with Wall Board

In covering cracked plaster ceilings, it is advisable to fur down from the joists to provide a nailing surface for the edges and centres of panels. First place the strips that cross the joints, making them run the full length of the room. When these are up, fit the other strips in between them. This ensures solid nailing at each joist for the long strips, while the short ones that miss the joists entirely may be fastened to the first solidly nailed strips.

Fixing Wall Board in the Attic

In finishing off the attic with wall board, extra " headers " are necessary where the side walls meet the slope of the roof and where the slope meets the ceiling. In placing the skirting " headers " plan on a 4-in. skirting instead of the usual 8-in. width. An 8-in. skirting is too high for the low side wall in the average attic.

Dealing with Curved Surfaces

Coved ceilings are sometimes desirable in large halls and public buildings, and wall board can be used to good advantage on these curved surfaces. Extra framing, suitably curved, between walls and ceiling is required. It is naturally desirable to avoid too sharp a curve, so that the panel will not bend under too great a strain.

How to Allow for Gas and Electric Fixtures

A gas or electric fixture suspended from the ceiling or coming through the side walls sometimes presents a difficulty. The easiest way to arrange for this is to detach the fixture and cut a hole in the wall board just large enough to fit round the pipe.

APPLYING THE PANELS

When all " headers " have been placed in the framework of the new room, or when whatever furring strips may be necessary are properly fastened, the wall board panels may be applied.

Fig. 1.—ONE OF THE MOST IMPORTANT STEPS IN THE ERECTION OF WALL BOARD IS THE PREPARATION OF THE WOODEN FRAMEWORK

Note how the wall has first been marked out with chalk, and wooden blocks inserted in the brick joints to afford easy nailing. (*By courtesy of Thames Board Mills Ltd.*)

Ceiling Work First—Using a "T"

Always apply the ceiling panels first. One man can apply them without assistance by making use of a "T" as illustrated to hold the wall board in place until he can drive temporary nails at the corners to keep the panel in the proper position while he completes the nailing operation. It often saves labour to give the ceiling panels the first coat of paint before putting them up.

The Nailing—Order of Working

Nail to the intermediate studding and joists first, starting at the centre and working out towards the edge. Use 1-in. flat-headed nails and place them 12 to 16 in. apart. Countersink them slightly, and before painting fill the holes with plaster of Paris.

When the centre nailing is completed, nail the edges, working from the middle to the corners; the nails should be placed from 6 to 8 in. apart. Place the nails at least $\frac{3}{8}$ in. in from the edges of the panel.

Wall Panelling

A very practical plan in placing the wall panels is to hang the panel by a temporary nail at the top centre. Then place temporary nails at each corner to hold the panel in position for the permanent nailing. Use the same kind of nails and space them in the same way as instructed for nailing ceiling panels.

Allowance for Expansion

Do not place the edges of the panels tightly against each other, but leave a space of from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. between all edges to allow for natural expansion.

INSULATING BOARDS ($\frac{1}{2}$ in.)

The non-resonant qualities of the many kinds of insulating boards now on the market make them effective in sound deadening. They are also effective insulators against heat and cold, and they can not only be used as ordinary linings to buildings but may be used as a plaster base.

APPLICATION OF INSULATING BOARD AS SHEATHING UNDER STUCCO, BRICK OR STONE VENEER, WOOD SIDING AND SHINGLES

Framing

Studs, joists, sills and plates should be framed as in ordinary frame construction, and should be placed accurately on 12-in. or 16-in. centres. Where end joints of insulating boards are necessary, use 4-in. by 2-in. "headers," cut in between the studs, to provide nailing base for all four edges.

Application

Insulating board should be applied vertically to the studding, and set in place so as to allow ample bearing for nailing all edges. Always space adjoining sheets $\frac{1}{4}$ in. apart at sides, top and bottom. Around the window and door frames bring the board to moderate contact with the frames. *Never force the board into place.* Nail an extra strip of insulating board to the back of frames to prevent leakage of hot or cold air.

Nailing

Use $1\frac{1}{2}$-in. by 13 S.W.G. galvanised slate nails with $\frac{5}{16}$-in. heads for $\frac{1}{2}$-in. sheathing and 2-in. by 9 S.W.G. nails for 1-in. sheathing. Nail the board first to intermediate studs, starting at the top, and space nails 6 in. apart; then nail around all four edges spacing nails 4 in. apart and at least $\frac{3}{8}$ in. from the edges. Nails should be driven so that the heads lie slightly below the surface.

Application of Stucco

Nail wood furring strips vertically through the board into each stud. Apply a metal lath suitable for a 16-in. span. If desired, self-furring metal lath may be used and applied direct to insulating sheathing. Apply stucco in accordance with manufacturer's specifications.

Application of Brick or Stone Veneer

Anchors or wall ties should be spaced to suit the brick or stone courses, and nailed through insulating board into the studs. Brick or stone should be laid in the usual manner, leaving at least $\frac{1}{2}$ in. space between the board and the stone or brick.

Application of Wood Siding

All types of wood siding or covering should be applied directly over the board, butting all joints on studs. Nail through into studs, using nails $\frac{1}{2}$ in. or 1 in. longer than usual, to allow for the thickness of the board.

Application of Shingles

Nail 2-in. by 1-in. wood furring strips over insulating board at right-angles to studs. Space strips as many inches apart as shingles are to be exposed to the weather. Nail shingles to the furring strips, using cut iron nails, preferably zinc dipped, or copper nails.

INSULATING BOARD AS PLASTER BASE

Insulating board can be used quite as satisfactorily as a plaster base, when a wire lath 3 in. or 4 in. wide should be placed over the joints. Insulating lath 18 in. by 48 in. long, full $\frac{1}{2}$ in. thick, with ship-lap edges, is also largely used, and when this is specified the following directions apply.

Framing

Studs, joists, and rafters should be true and set accurately on 12-in. or 16-in. centres.

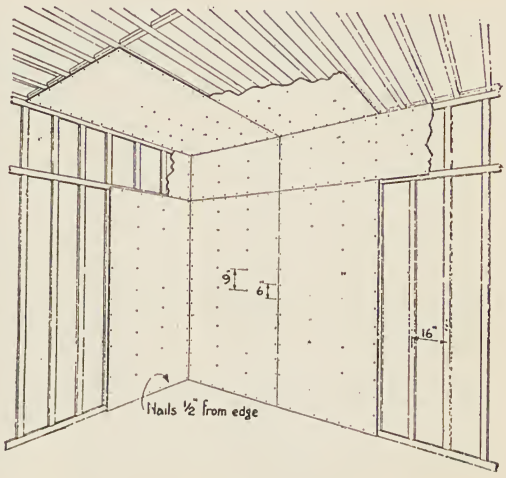


Fig. 2.—DETAILS OF FRAMEWORK AND METHOD OF FIXING "TURNALL" ASBESTOS WALL BOARD. (*Asbestos Cement Building Products Ltd.*)

Application

Insulating lath should be applied with the long edges at right-angles to the framing and the vertical joints on course should be staggered with the joints of the preceding course. Space sheets $\frac{1}{4}$ in. apart at all vertical joints and centre these joints on the framing. Bring the ship-lapped joints of insulating lath to moderate contact, and also around window and door frames bring the insulating lath to moderate contact with the frames. *Never force insulating lath into place.* It is not necessary to dampen before applying.

Nailing

Insulating lath should be nailed securely to frame, using $1\frac{1}{4}$-in. by 13 S.W.G. galvanised slate nails for $\frac{1}{2}$-in. lath and 2-in. by 9 S.W.G. galvanised slate nails for 1-in. lath. Space nails $5\frac{1}{2}$ in. apart at least $\frac{1}{2}$ in. from the ship-lapped edges and $\frac{3}{8}$ in. from the ends. Nail first to intermediate studs, then nail the ends.

Preparation for Plastering

At all internal vertical angles and at all corners between ceiling and walls use 8-in. strips of painted metal lath or galvanised wire lath bent at right-angles to form two 4-in. legs and nail or staple lightly at outer edges. Across the corners of all door and window frames staple lightly 8-in. squares of the same material. Use metal corner beads for all external angles. Do not wet insulating bath before plastering.

Plastering

Use quick-setting gypsum plaster, applied according to manufacturer's specifications. Use two or three coats having a total thickness of not less than $\frac{3}{8}$ in. The brown coat should be thoroughly dry before applying the final coat. Use a darby long enough to span two studs or joists, in the direction of the studding or joists. All rooms should be well ventilated

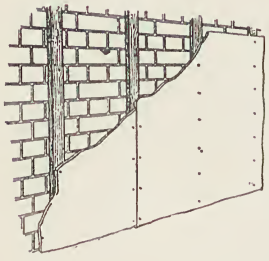


Fig. 3.—BATTENS ERECTED FOR FIXING WALL BOARD TO BRICK WALL

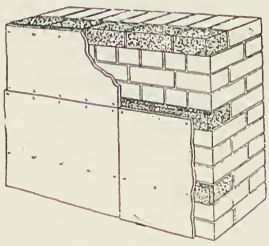


Fig. 4.—WALL BOARD NAILED TO BREEZE BLOCKS BUILT INTO THE WALL

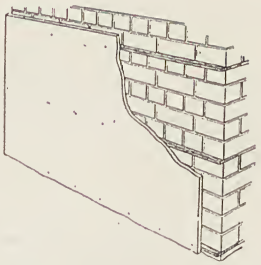


Fig. 5.—WALL BOARD NAILED TO WOOD STRIPS BUILT INTO BRICK WALL

to allow the plaster to dry. Moisture will not pass through insulating lath, and can only be carried off by adequate ventilation. In cold weather care must be taken to prevent the freshly applied plaster from setting too quickly.

INSULATING BOARD FOR INTERIOR FINISH, WITH OR WITHOUT PAINT, STAIN OR DISTEMPER

Framing, Application and Nailing

Follow same framing application and nailing specifications as detailed previously for sheathing. Where special panelling effects or chair rails are specified, 4-in. by 2-in. "headers" should be cut in between the framing for nailing base. Where nailheads are not to be covered with wood battens, use 1½-in. galvanised oval nails driven at an angle and cover up nail holes by rubbing surface lightly with another piece of the board. Wood battens, where used, should be at least 2 in. wide, or insulating strips should be 3 in. wide with edges bevelled or slightly rounded with sandpaper.

Finish

Where the natural finish of insulating board is to be used without further treatment, apply panel strips as specified, after allowing paint or stain on the strips to dry thoroughly. Where surface is to be treated with oil paint, first apply evenly one coat of any good glue sizing or priming, and allow to dry thoroughly before painting. Apply paint in usual manner. Where stain or distemper is used, apply direct without preparation according to manufacturer's specifications. One coat of surface decoration should be applied always before the cover fillets are fixed over the joints.

INSULATING BOARD FOR INSULATION OF ATTICS AND FLOORS

Framing

Studs, joists and rafters should be framed as an ordinary frame construction, and should be placed accurately on 12-in. or 16-in. centres.

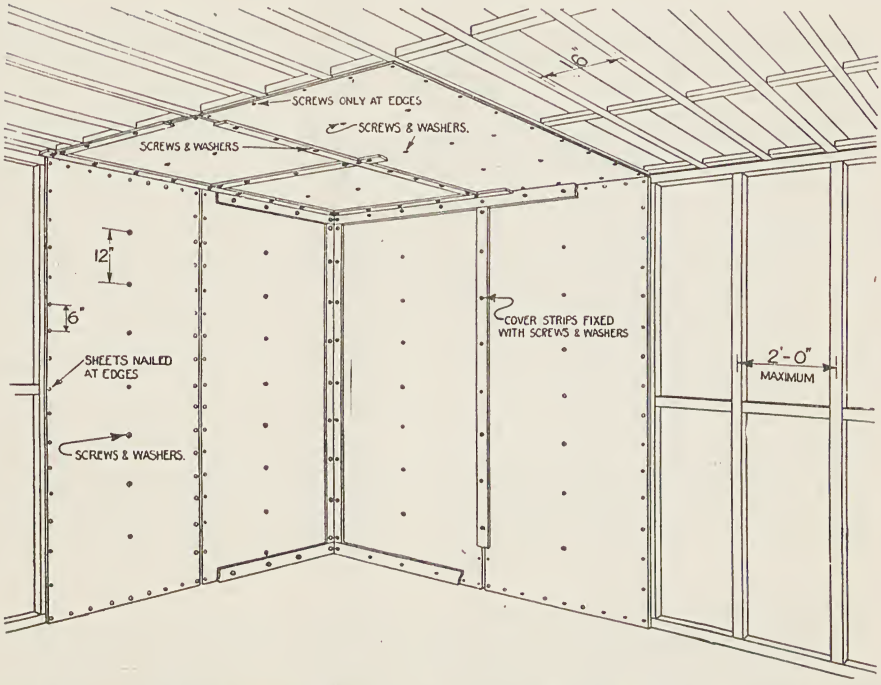


Fig. 6.—DETAILS FOR FIXING "TURNALL" ASBESTOS WOOD BOARD. (*Asbestos Cement Building Products Ltd.*)

Where end joints of the board are necessary, use 4-in. by 2-in. "headers," cut in between the framing to provide nailing base.

Floor Insulation

Apply insulating board on joists, and under finish floor, bringing sheets to moderate contact, with only sufficient nails to hold in place while laying finish floor. Where external dimensions permit, an even greater degree of insulation can be achieved by nailing 2-in. by $\frac{5}{8}$-in. (or similar) wood strips through insulating board to joists and laying the finish floor on these. The air spaces thus created will represent another asset in eliminating sound transmission.

Attic Insulation

Walls and ceilings of attic should be finished with insulating board as per specifications detailed above for interior finish. All corner joints in attic should be brought to moderate contact, and all spaces where air leakage might occur along the eaves should be blocked off with the board.

INSULATING BOARD FOR INSULATION OF SLOPING OR PITCHED ROOFS

Framing

Rafters should be placed accurately on 16-in. centres and 4-in. by 2-in. "headers" cut in where end joints occur.

Application

Apply the board lengthwise to the rafters, allowing ample bearing for nailing all edges. Space adjoining sheets of insulating board $\frac{1}{4}$ in. apart. At all vertical projections, and at meeting of roof insulation and wall sheathing, insulating board should be brought to moderate contact. *Never force the board into place.*

Nailing

Use $1\frac{1}{2}$-in. S.W.G. galvanised slate nails with $\frac{5}{16}$-in. heads, and nail the board first to intermediate studs, then around edges, spacing nails 6 in. apart.

Application of Roofing

Waterproof paper need not be used. Nail 3-in. by 1-in. furring strips or ordinary $\frac{7}{8}$-in. roof boarding through the insulating board to the rafters, spaced as necessary for the roofing to be used. Apply shingles or roofing to the furring strips or roof boarding in usual manner.

INSULATING BOARD FOR INSULATION OF FLAT ROOFS

For special insulation of all flat roofs insulating board proves a valuable asset.

On Flat Concrete Roofs

The roofs should be clean and dry when a heavy uniform coat of bitumen should be applied, using not less than 30 lb. per square. Insulating board should then be laid on to the bitumen whilst it is hot and firmly pressed into place, making sure that all edges are well pressed in. If more than one layer of insulating board is to be used, cover the top surface of each layer of board uniformly with bitumen and press the successive layers of board well down while the bitumen is still hot.

On Wood Roofs

Insulating board should be nailed with $1\frac{1}{2}$-in. by 13 S.W.G. galvanised slate nails. Nail first at random in the centre of the board, then every 12 in. around all edges set in not less than $\frac{3}{8}$ in. from the edge of panels.

Where only one layer of insulating board is specified, cover the wood roof with a sheet of resin-sized paper to prevent any bitumen dripping through. If more than one layer of insulating board is specified, only sufficient nails to hold in place need be used for the first layer. Nails of sufficient length to enter wood roof at least 1 in. driven flush should be used. Nail final layer of insulating board at random in centre of board and around all edges every 12 in. set in from the edge at least $\frac{3}{8}$ in. Apply roofing according to manufacturer's instructions. Only sufficient insulating board which can be properly covered by roofing should be laid in any one day.

Insulating Board as Exterior Finish

For inexpensive types of construction insulating board may be used and left exposed to the weather. Apply as directed for sheathing, using 2-in. by 9 S.W.G. galvanised nails for intermediate studs and $1\frac{1}{4}$-in. by 13 S.W.G. galvanised slate nails for the edges of the sheets. Paint according to painting specification already given and cover all joints with 3-in. wood battens.

NOTES ON FITTING "TURNALL" ABSESTOS WALL BOARD

"Turnall" asbestos wall board can be easily cut with a fine saw or chisel and can be fixed by nailing or screwing.

Fixing to Brick or Concrete Walls and Ceilings

Fig. 2 shows the method of fixing. A solid nailing-surface must be provided for all edges of each piece, regardless of shape or size. It can be fixed to the under side of floor joists, provided these are not more than 16 in. apart. When covering walls, they should be battened with 2-in. by $\frac{3}{4}$-in. sawn battens spaced at not more than 16-in. vertical centres. Nails or screws should be placed at 6-in. intervals along the edges and 9-in. intervals over intermediate supports. Nails should be not less than $\frac{1}{2}$ in. from the edge of the board. If the nails are to be covered, use $1\frac{1}{4}$-in. by 13's gauge compo-coated nails. If the surface is not to be covered, the nails should be concealed as shown in Fig. 7.

Two methods of fitting to walls are shown in Figs. 4 and 5. Fig. 4 shows the wall board nailed to breeze blocks built into a brick wall; Fig. 5, wall board nailed to wood strips built into a brick wall at not more than 16-in. centres.

Joints between Boards

Joints between boards can be covered over with wood cover-strip of plain or moulded section. Joints between wall and ceiling can be

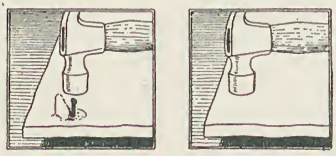


Fig. 7.—METHOD OF HIDING NAILS WHEN SURFACE IS NOT TO BE COVERED

covered with a cornice mould. Another method is to use an embossed paper strip, using a good, strong paste. If the wall board is to be painted and an invisible joint is required, a linen strip should be fixed over the joint with paste.

Oil paints, distemper, and water paints can be applied direct to the surface of "Turnall" asbestos wall board. In the case of oil paints, priming with boiled oil and turpentine, or turpentine substitute, and allowing it to dry, will considerably help the painting.

Plaster Wall and Wood Fibre Boards

Modern methods of fixing plaster wall boards and the wood fibre wall boards, now coming into extensive use, are described in the next section, which also includes a pictorial section showing the erection of a partition of wall boards.

QUESTIONS AND ANSWERS

When designing the Panelling for a wall, how would you deal with Doors and Windows ?

Each window or door should be considered as running the full height of the room, and the wall area divided up, as far as possible, into uniform panels.

What is the minimum recommended size for cover fillets ?

$\frac{3}{8}$ in. by $2\frac{1}{2}$ in. wide.

How should a Brick or Concrete Wall be prepared for Panelling ?

Wood strips $\frac{7}{8}$ in. by $2\frac{3}{4}$ in. wide should be nailed or screwed vertically to the surface, using suitable wall-plugs. Headers must be similarly fixed immediately above skirting, chair rails, or other wood cover fillets.

When Panelling a Room, what part should be panelled first ?

Always apply the ceiling panels first. It is a good idea to give the ceiling panels the first coat of paint before putting them up.

WALL BOARD ERECTION

(Continued)

PLASTER WALL BOARDS

Preparing the Wall

Plaster board is easy to apply, but time is saved and a better result is achieved by careful planning of the job. Have it brought on the job and piled on edge along the wall, face out. It is better handled by two men, and preferably not placed in the room until all plumbing and electric rough-in work is complete.

Spacing, Studding and Joists

When plaster board is specified before the studding and joists are in place, considerable time and expense will be saved by seeing that they are spaced on 16-in. centres, and avoiding as far as possible the use of any studs and joists that are warped or crooked or not sized.

Providing " Headers " and Blocking

All four edges of plaster board must be nailed. The only exception that may be allowed to this rule is where the ends of the slabs on the ceiling come hard up against the vertical wall face. In this case the side wall slab below forms a shelf for the support of the end of the ceiling slab. In all other cases, 2-in. by 4-in. " headers " must be placed between studdings and joists for nailing the ends of the slabs of plaster board. It is recommended that " headers " be provided for nailing the skirtings. *No grounds are required.* Bowed or warped joists or studs should be replaced or straightened.

Framing of Openings

See that there is backing for nailing all edges of the plaster board at the openings. Where standard window framing is furnished, pull frame out of opening $\frac{3}{8}$ in. by inserting lath between outside casing and sheathing to allow for difference in thickness between standard lath and plaster and plaster board. This will save building out on studs all along the wall. Fit siding close to window frame.

Framing for Chimneys

Do not nail plaster board furring direct to chimneys. Fur with 1-in. by 4-in. strips to provide nailing surfaces for all edges of the plaster board.

Fig. 1.—ERECTING A WALL-BOARD PARTITION (SOUND-INSULATING)
Showing general arrangement of studding.

Fig. 2.—ERECTING A WALL-BOARD PARTITION
Two rods are used, as shown, to measure the height of the room.

Nail these furring strips together at the corners, to the floor and ceiling and to the wall, *but not to the chimney itself.* This will allow freedom of movement of the chimney.

Brickwork

On new brick walls to be covered with plaster board, set nailing strips in the mortar joints every sixth course. On old brick walls, drive wood blocks in the mortar joints to serve the same purpose of providing for nailing of furring strips. Use 1-in. by 2-in. timber for the furring strips to provide nailing surface for all edges of the plaster board.

Corner Beading

Install corner beads, if they are to be used, before plaster boarding, attaching them to the framing. See that they are set straight and plumb so as to finish flush with the surface of the plaster board.

APPLYING PLASTER BOARD

Plan the work carefully before starting to nail the plaster board in place. This will save much in time and material and ensure a neat, finished job. Remember that nothing will cover the finished wall but the paint or paper used as exterior decoration.

Examine the Framing

Examine the rough carpentry to see that it is properly installed to receive the plaster board and that all plumbing, lighting and heating connections are in place and have been inspected. See that all studding and joists are in line and that necessary " headers " have been put in to provide nailing surface for the ends of the plaster board slabs.

Allow for Spacing of Joists and Studs

If joists and studs do not space evenly when starting from any of the walls, for the reason that the last joist or stud is not set on 16-in. centre, then start from a joist or stud that will give the proper spacing, usually one or two from the wall. Then cut a piece of plaster board that will fit the space between the first slab and the wall. This will save considerable blocking when the third stud or joist is not on a centre 48 in. from the wall.

Cutting, Fitting and Nailing

Pile the plaster board slabs on edge along the wall, face out. To cut, score on the face side with a knife, cutting the front liner. Bend part to be cut off backward, giving the back of the board a slight blow along the line of the intended break. This will break the gypsum core. Then cut the back paper liner with a knife along the line of the bend, and the cut is completed. Plaster board may be cut with a hand-saw if preferred.

Fig. 5.—ERECTING A WALL-BOARD PARTITION
The length required is next marked on the board.

Fig. 6.—ERECTING A WALL-BOARD PARTITION

Draw the line for the saw cut by pressing the pencil point against the end of the steel rule, and draw both along together.

Fig. 7.—ERECTING A WALL-BOARD PARTITION

When sawing the board the waste piece is pressed down, to allow the saw free action and prevent binding.

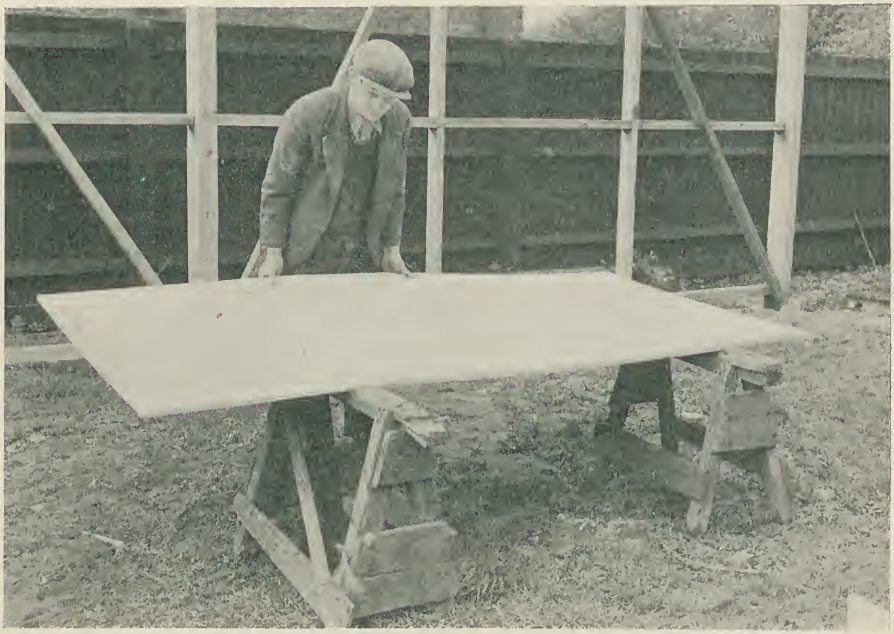


Fig. 3.—ERECTING A WALL-BOARD PARTITION
The board is placed on trestle supports prior to marking off length required.

Fig. 4.—ERECTING A WALL-BOARD PARTITION
Place the measuring rods on the board.

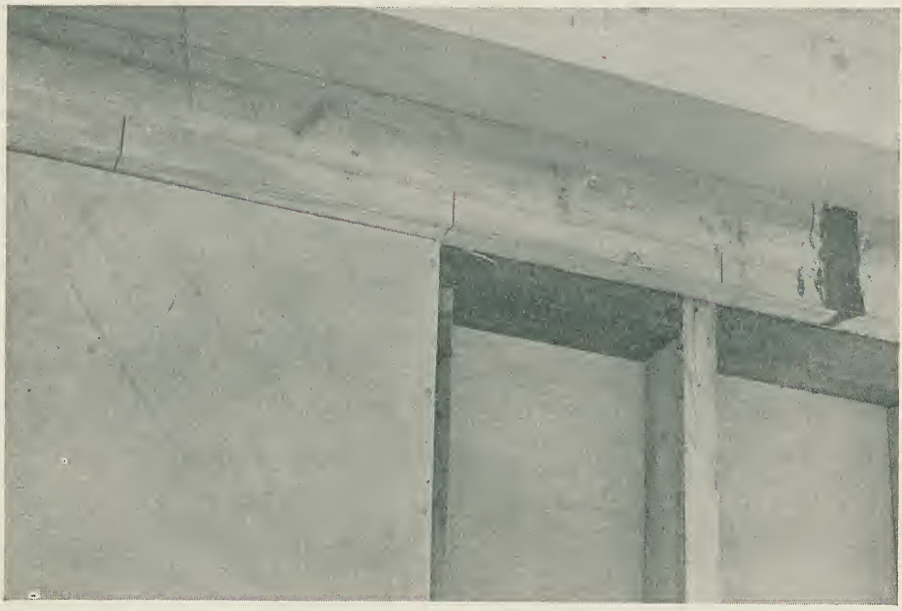


Fig. 8.—ERECTING A WALL-BOARD PARTITION

Pencil-marks are made on the joists to indicate the position of studding, to ensure that the nails are driven in in the correct positions.

Fig. 9.—ERECTING A WALL-BOARD PARTITION

Temporary nails are put on the first board, starting in the corner of the room.

Arrange to break or stagger end joints between courses in all cases, particularly on ceilings. Place the long dimensions of the plaster board slab lengthwise of the joists or furring on ceiling. On side walls pieces of plaster board should extend from the ceiling to within about $\frac{1}{2}$ in. of the floor. Butt all joints between slabs of square-edged plaster board.

For nailing plaster board use $1\frac{1}{2}$-in. French nails. Nail intermediate supports first, working from the middle towards the ends of the slabs. Then nail the edges.

Drive all nails home, depressing the heads slightly below the face of the board, but *not* right through the fibre surface. All ceiling nailing should be about 10 in. between nails. On side walls, place nails at intermediates 12 in. apart and at edges 5 or 6 in.

Place nails about $\frac{3}{8}$ in. from the edge of plaster board slab. *Do not make the mistake of nailing at closer intervals*, as it tends to split the core.

By actual test, each nail will support many times the weight it is called upon to support by the above nailing arrangement. The frequency recommended is sufficient to iron out the board.

Apply with the finish surface exposed in all cases. The back surface usually bears the trade mark and other markings.

Apply the Ceiling First

Plaster board can be easily applied by two men. The application is simplified by using " T "-heads, consisting of a 2-in. by 2-in. upright and a cross-piece of 1 in. by 2 in. about 12 in. long. These " T "-heads should be ceiling high. The slab of plaster board to be applied is lifted into place, face down, and held there by the " T "-heads, located at about three points and sprung into place. It is recommended that light lines should be drawn on the surface of the slab to locate the position of the centre joists for nailing.

Then the Side Walls

After the ceiling is all nailed, apply the side walls. Bring the top edge of the side walls up flush with the surface of the ceiling slabs, and the lower edge about $\frac{1}{2}$ in. from the floor.

Partitions

Where possible, apply plaster board to the ceilings and side walls first and then erect the intermediate partition framing. This will simplify the work, reducing the cutting and blocking.

Applying Over Old Plaster

In plaster boarding over old plaster ceilings, nail furring strips of 1-in. by 2-in. or 1-in. by 3-in. timber crosswise of the joists on 16-in. centres. Nail cross-pieces between these to act as " headers " for nailing the ends of the slabs, arranging to break joints between courses. When furring the side walls it is better to rout out the plaster along the studs and use strips of such thickness as to come flush with the surface of the

Fig. 10.—ERECTING A WALL-BOARD PARTITION
Placing an adjoining board in position prior to nailing.

Fig. 11.—ERECTING A WALL-BOARD PARTITION
Showing the slight gap left between the boards.

Fig. 12.—ERECTING A WALL-BOARD PARTITION
The nail heads are filled in with plaster of Paris.

Fig. 13.—ERECTING A WALL-BOARD PARTITION
Pasting thick paper strips before applying to boards to cover joints and nail holes.

Fig. 14.—ERECTING A WALL-BOARD PARTITION
Applying the paper strips to the joints between the boards. Any standard wall finish may now be applied.

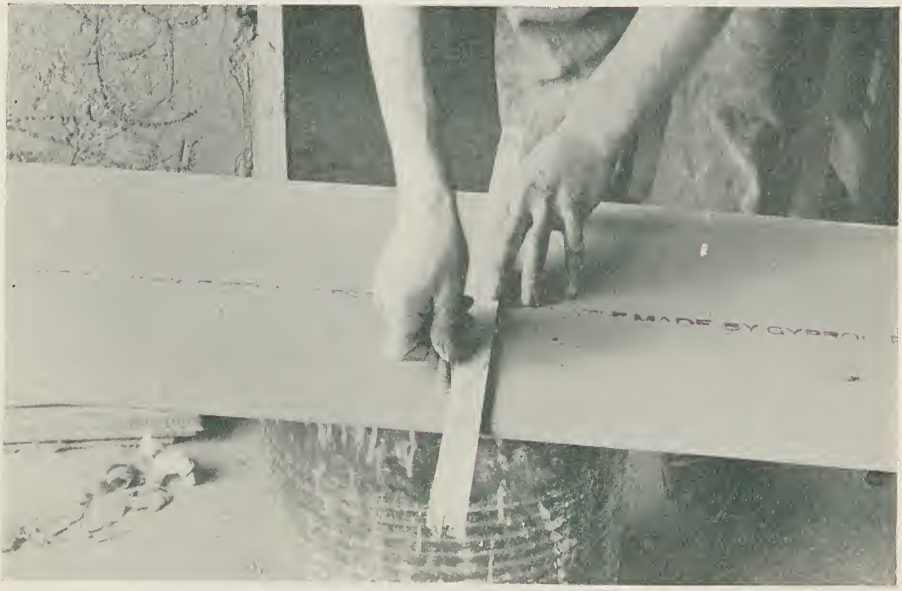


Fig. 15.—CUTTING PLASTER BOARD (1)
First score a line on the face-side of the board.

Fig. 16.—CUTTING PLASTER BOARD (2)
Now bend the part to be cut off.

Fig. 17.—CUTTING PLASTER BOARD (3)
The back liner is now scored along the line of the bend.

plaster when nailed in place in the channels thus formed. Any uneven places should be made level. Apply the plaster board in the usual way, fitting it around the openings, and apply moulding at the openings to complete the finish.

Finishing the Plain Wall for Paint or Paper

When the walls and ceilings are to be decorated with wallpaper or to be painted without panelling, all joints and nails should be filled in with the specially prepared filler supplied with the board. They are not difficult to fill, but careful work is necessary to ensure smooth, perfect walls and ceilings.

Preparing the Joint Filler

Mix in small batches on a clean mortar-board. Sprinkle the filler into the water. Mix with a clean trowel to the consistency of ordinary plaster. The filler furnished is usually timed to set in 1½ hours. Vinegar-water to the proportion of 8 oz. vinegar and 12 quarts water will retard it 1 to 1½ hours. Some plasterers prefer glue-water as a retarder. Alum-water to the proportion of a pound to a pail of water will accelerate it as much as is practicable for good work.

Roughing-in the Joints

First dampen the joints to be filled, with a brush. Then force the filler firmly into the joints with a scraping knife. As the last stroke, tip the knife on end and draw down the length of the joint to rough it up for receiving the finish coat. Allow this to set hard before applying the finishing filler.

Finishing the Joints

When the rough, filled joint has set hard, dampen it and apply the finish coat. Mix the finish plaster in the same manner as for the rough-in, but slightly thinner. Apply in a thin layer, trowelling out to a smooth even surface flush with the surface of the plaster board. Trowel each side to a feather edge, but not wider than necessary. The whole wall surface should be absolutely even after the completion of the joint filling.

Finishing Corners and Angles

Joints and corners and angles are finished in the same manner as the edges. Where corner beads are not used for external corners, and either slab does not entirely fill out the corner, set a straight-edge, or arris, along the face of the plaster board on one side so that it locates the exact position of the finished corner. Fill out in the first filling operation with filler flush with the straight-edge. When the filler has set sufficiently, remove the straight-edge. In the second operation, smooth out to a feather edge as on other joints. Spot the nails with filler and trowel out in a feather edge, leaving the surface flush with the surface of the plaster board.

We are indebted to the Patent Impermeable Millboard Co., Ltd., for facilities to take the photographs showing the erection of a wall-board partition.

SETTING OUT A BUILDING

WHEN an architect has been commissioned to build a house, he first prepares a drawing comprising plans, elevations, and sections, and a " site plan " or " block plan."

Plans Must Be Submitted to the Local Surveyor

Before any start can be made by the builder, the architect first deposits a copy of this plan with the local surveyor, who puts it before his committee for approval. The local surveyor then notifies the architect that his plans have been approved (or otherwise), and if approved, the architect will instruct his builder to commence the work.

The builder will be supplied with a copy of the approved plan, and his first job will be to go to the site and set out the foundations.

The Site Plan

The site plan or block plan is of first importance in setting out a building.

The copy of the drawing deposited with the surveyor has to have

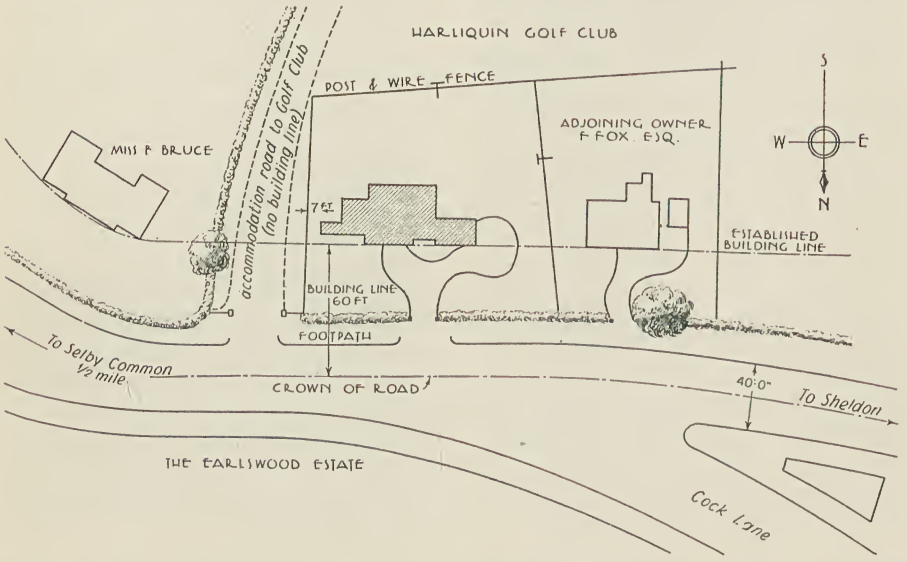


Fig. 1.—A TYPICAL SITE PLAN AS SUPPLIED BY AN ARCHITECT TO GIVE THE BUILDER THE INFORMATION HE REQUIRES TO SITE THE BUILDING ACCURATELY

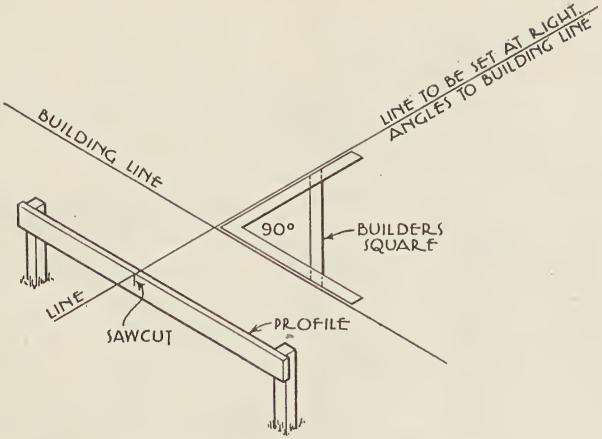


Fig. 2.—SETTING OUT A BUILDING

Showing method of setting up a line at right angles to the building line by using the builder's square.

upon it, under the by-laws of the local authority, a site plan. This must be sufficiently accurate and complete in details to show clearly the position of the house on the site, together with paths and approaches. Furthermore, the site plan must indicate clearly and accurately the position of the adjoining roads, paths, building line, boundaries, and adjoining properties, sufficient for the surveyor or his committee to identify easily the position and locality of the site.

The second function of this site plan is to supply to the builder the information he will require to enable him to "site" the proposed house to the architect's requirements.

Importance of Correct Siting

The surveyor and his committee have to consider the siting of the house in addition to the construction and drainage, etc., and a building which has been incorrectly set out or sited by a builder will have to be rectified before the surveyor will pass the foundation work.

The accompanying illustration shows a typical site plan as supplied by an architect to give to the builder the information he requires accurately to site the building.

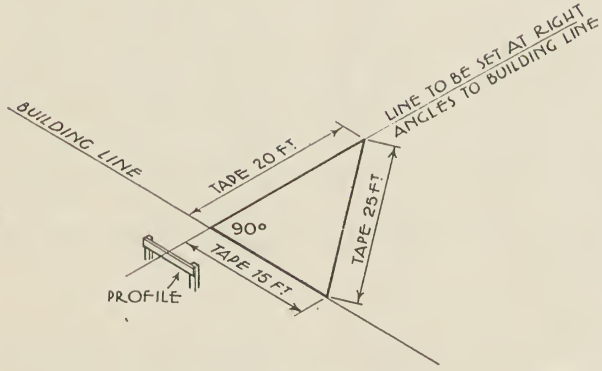


Fig. 3.—SETTING OUT A BUILDING

Showing method of setting up a line at right angles to the building line by using two tapes.

The Building Line

From this plan it will be seen that the most important line is the building line, shown as a dotted

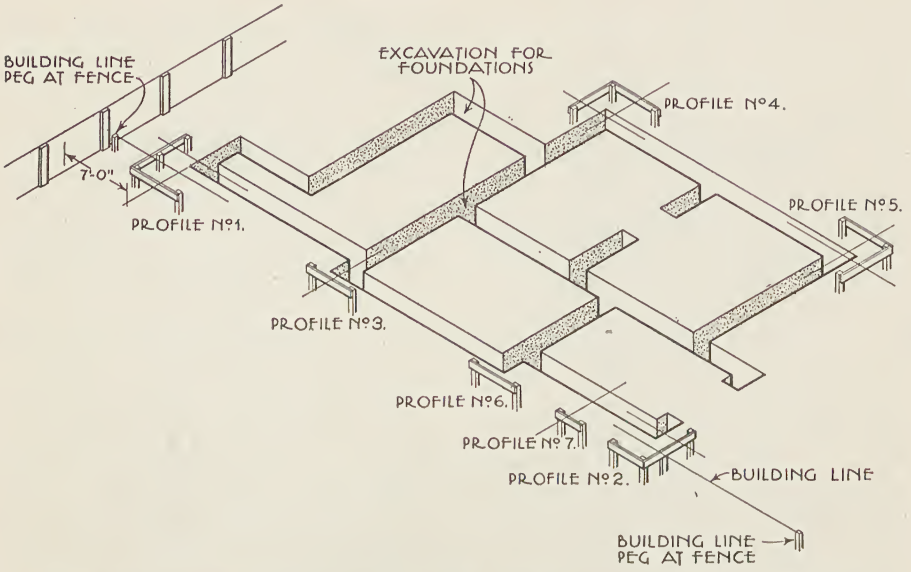


Fig. 4.—DIAGRAM SHOWING HOW PROFILES ARE ERECTED AND NAILED TO PEGS

line across the site. This is the first thing to be located, and will be pegged out at the correct distance from and parallel to the centre of the road as indicated.

No portion of the house, other than porch or suchlike, is to extend to the road side of this line.

PROCEDURE ON THE SITE TO SET OUT A BUILDING

As the building line is the first line to be established, this should be fixed by taping the distance of, in this case, 60 ft. from centre of road, through the existing hedge on to the site, and close against the west boundary fence. Knock in a peg at this point on the site, and similarly at the east boundary. The reason for choosing the extreme ends of the building line for pegging is to make quite sure that there will be no need to move or disturb these pegs while the building is in progress. A bricklayer's line must now be drawn tightly between these two pegs sufficiently high to avoid the line sagging on to the ground. It may even be necessary to dig up some obstructing growth, or to form a narrow trench in places under the line.

Setting Out for Foundations

The sequence of operations in setting out for the foundations is very similar to that which one would take in setting out a rectangle or regular shaped figure with tee-square and set-square on a drawing-board, with the difference that the tee-square is substituted by a line tightly

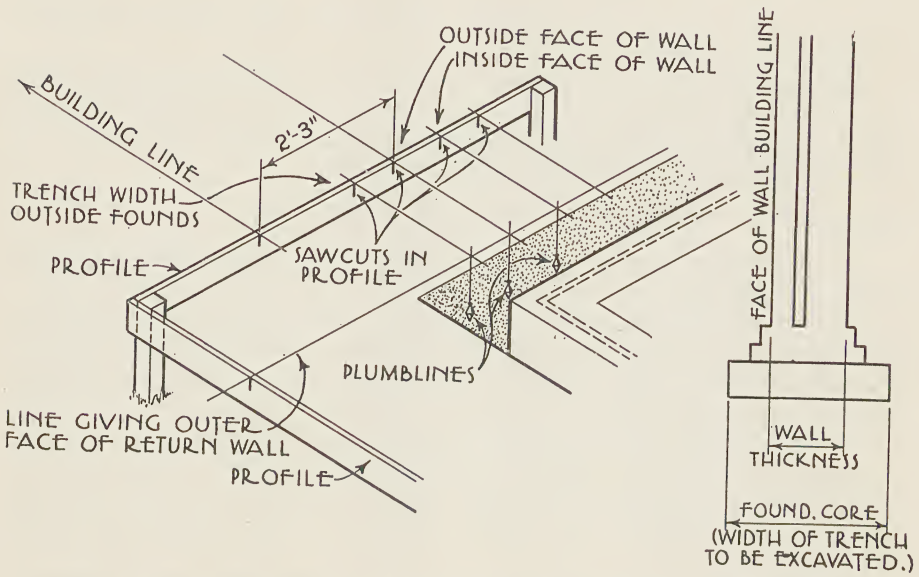


Fig. 5.—Enlarged view of the markings and lines on corner profile

drawn between two pegs, and the set-square by an ordinary builder's square.

The Front Wall

The front wall of the building will be set out on this line, which is now established as the building line. A point along this line must now be established which will give the position of one of the return walls.

The Return Walls

There is a dimension 7 ft. from the west boundary to the west wall of the building. Turning to the $\frac{1}{8}$-scale plan, add up the dimensions of the external wall from extreme west to wall angle at which it is proposed to establish the return wall. This done, the procedure is to set up at this point on the building line a line at right angles to the building line.

How the Right Angle is Established

This right angle is accurately established by (1) the builder's square, or (2) by working with two tapes and proving the right angle by measuring along the two directions 3 ft. and 4 ft. respectively, and closing the triangle with the dimensions 5 ft. The angle the two tapes make, where the 3-ft. side joins the 4-ft. side, is 90° when the third dimension is 5 ft. Other dimensions of sides may be taken providing the dimensions are in

the ratio of 3 : 4 : 5. The larger the dimensions, the higher the degree of accuracy obtained.

Having established one corner or angle of the building by lines, it is immediately necessary to establish this setting out in a more permanent form. All lines must be taken up at the end of the day's work, and they must be readily replaced at any required time.

Profiles

For this reason profiles must be erected, and nailed to pegs as shown in the illustrations.

The profiles at west and east of site should be erected first, and the building line transferred to these by plumbing down from the established line, and marking with a saw-cut—see enlarged sketch of the markings and lines on corner profile.

The next profiles to establish are those which will find the right angle to the building line, for example, Nos. 3 and 4. These two are chosen because they will give a long line for right angle and can the more easily be set up and checked—see sketch showing setting up of right angle to building line.

With these two lines established it is a quite straightforward procedure to complete profiles 5, 6, and so on, until all angles of trenches and brickwork are accurately set out and established by saw-cuts on the necessary profiles.

One cannot stress too much the importance of carefully and accurately establishing profiles for any building work. If all necessary profiles are erected in the early stages, before the excavations are started, they will be of great importance when the setting out of brickwork is commenced and, in the more difficult case of steelwork, when the structural steel erectors are ready to line up and grout the bases of stanchions

Large Building Works

In the case of large building works, the elements described here are the basis of very elaborate setting out, the general difference being that the right angles are set up with precision instruments. Profiles are constructed of stout timbers, and bolted, and all pegs are concreted in to ensure that they are not disturbed. In such cases it is often necessary for the foreman, who is setting out, to refer back and to check back on his original profiles as long as one or even two years after they have been established.

COPPER FOR SANITARY WORK

THE use of copper in buildings has increased considerably in the past few years, especially in the form of tubes for the conveyance of domestic water supplies and waste water. Copper sheet for roofing purposes is also largely used in preference to other materials. The introduction of light-gauge copper tube, and the various types of joints for connecting them, brought the use of this material to the fore-front in the equipment of sanitary installations, and we now have hot- and cold-water services, traps, waste and ventilating pipes executed wholly in copper.

Comparison with Lead

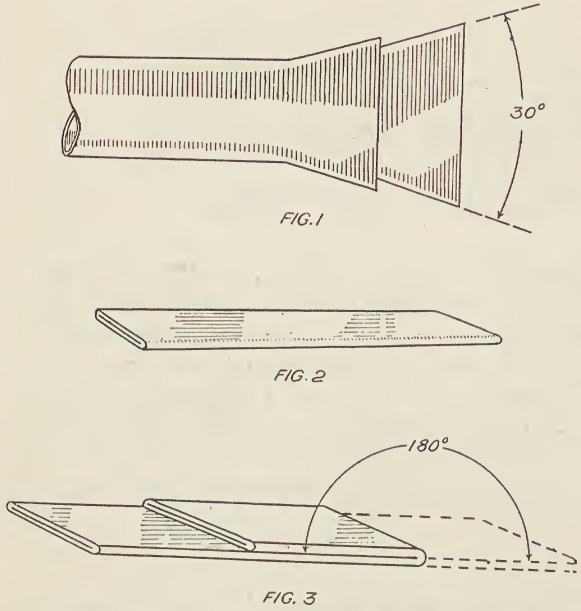
Copper is extremely malleable, which enables it to be readily manipulated, so that it may be rolled into very thin sheets, drawn into wire, or drawn into thin-walled tubing. It is not so readily manipulated by hand work as lead, and it toughens with cold working, which means that occasional annealing must be carried out if extensive working of the metal is required.

TUBES

The bending of the smaller sizes of copper tubes may be carried out with the aid of a bending machine, but the larger sizes require loading with sand, pitch, or resin in order to bend them. Another method of bending is the hydraulic process, in which the tube is charged with water, sealed, then heated and bent. Lead pipe of all sizes presents no difficulty where bends are concerned, and is easily manipulated to suit any position, and the tools required are few and inexpensive. The labour incurred in the bending of copper tubes of the larger diameters is claimed to be offset by the advantages the metal possesses over other materials for many classes of work.

Smoothness

The perfectly smooth nature of copper tube renders it eminently suitable for the distribution of water to, and the carriage of waste water from, sanitary fitments. Very little friction is set up, and the smooth interior does not permit of waste matter adhering thereto. Being a non-ferrous metal no rusting occurs, consequently the bore is not restricted,



Figs. 1, 2, 3.—B.S.S. TESTS ON COPPER TUBES

as often happens with iron pipes, and discoloration of the water due to rust does not arise.

Rigidity

The rigid nature of copper, when compared with lead, renders it to a great extent self-supporting, therefore less fixing is required.

Ease in Handling

Owing to the light nature of the tubing it can be handled with greater ease than either lead or iron pipe, and preparation for jointing is such a simple matter that much time is saved.

Weight

The lightness of copper tube compared with iron and lead is a great point in its favour. The strength of copper is such that tubes with very thin walls can be used with safety for very high pressures where water services are concerned; and for waste, soil, and ventilation pipes copper of a comparatively light weight is permitted.

Relative Weights

As an example of the great difference in weight, the relative gauges of 2-in. pipe for soil, waste, and ventilation purposes as required by the L.C.C. drainage by-laws are as follows :—

Copper not less than 4·17 lb. per yard.

Lead not less than 10 lb. per yard.

Cast iron, including socket and beaded spigot, 24 lb. per 6-ft. length (approximately 12 lb. per yard).

For water-supply pipes the light-gauge tube specified in the by-laws of the Metropolitan Water Board and in the Ministry of Health Model By-laws (No. 21) is given as *three gauges lighter* than the British Standard Specification for copper tubes having screwed threads. The relative weights of copper, lead, and iron pipes for use on water services are given in Table I.

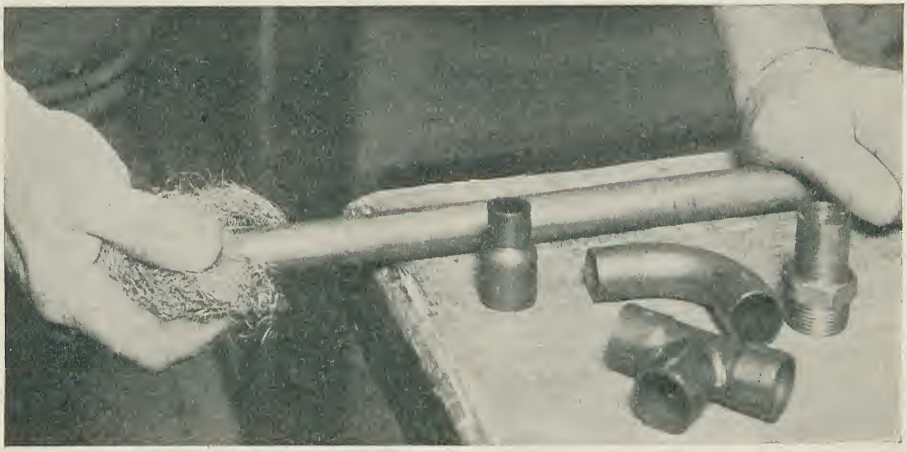


Fig. 4.—CLEANING TUBE WITH STEEL WOOL BEFORE FORMING SOLDER JOINT IN COPPER TUBE WITH ONE OF THE FITTINGS SHOWN

TABLE I

WEIGHT IN LB. PER FT. RUN FOR WATER PIPES

Internal Bore in In.	*Copper*		*Lead*		*Iron*	
	Gauge	*Weight*	*Mains*	*Distributing Pipes*	*Water Strength*	*Steam Strength*
$\frac{1}{2}$	18	0·32	$2\frac{1}{3}$	$1\frac{2}{3}$	0·896	0·973
$\frac{3}{4}$	18	0·46	$3\frac{2}{3}$	$2\frac{2}{3}$	1·268	1·403
1	17	0·71	$5\frac{1}{3}$	$3\frac{2}{3}$	1·833	2·008
$1\frac{1}{4}$	17	0·88	7	$4\frac{2}{3}$	2·598	2·827
$1\frac{1}{2}$	17	1·05	9	6	3·237	3·500
2	16	1·60	$12\frac{2}{3}$	8	4·128	4·473

Specification

If the use of copper tube is decided upon for any installation, care should be taken to ensure that the tube is of the best quality. Inferior tube, made from old scrap or produced from redrawn old tubes, should be avoided, as it will give trouble in some form or other, such as pollution of the water or destruction of the tube by pitting. A model specification is given here, together with extracts from the British Standard Specification for light-gauge copper tubes No. 659-1936.

MODEL SPECIFICATION FOR COPPER TUBES*

Tubes to be made from hot pierced or extruded shells from solid cast deoxidised billets cast in the works of the tube maker from virgin copper, to which has been added not more than 25 per cent. of manufacturing scrap made in the works of the tube maker and resulting from tubes made to this specification.

* Yorkshire Copper Works Ltd.

Fig. 5.—MAKING A SOLDERED FITTING CONNECTION—FIRST OPERATION

Prepare the copper pipe to be joined by cleaning with steel wool. Be sure that all traces of oxidation are removed. Parts should be bright copper colour.

Fig. 6.—MAKING A SOLDERED FITTING CONNECTION—SECOND OPERATION

Apply an even coat of non-corrosive soldering flux. The above shows a flux in the form of a stick which is easy to apply.

Fig. 7.—THIRD OPERATION

Now clean the fitting with steel wool to remove all traces of oxidation.

Fig. 8.—FOURTH OPERATION

Apply even coat of soldering flux to the inside of fitting. Note pointed stick of flux.

Fig. 9.—FIFTH OPERATION

Slip the pipe into fitting until it is tightly seated against stop.

Fig. 10.—SIXTH OPERATION

Apply blow-lamp or torch flame to outside of socket until flux begins to boil.

Fig. 11.—SEVENTH OPERATION

Test heat by touching edge of fitting with wire solder. If hot enough, solder will melt and flow, filling cavity between wall of pipe and fitting almost instantly.

Fig. 12.—FINAL OPERATION

Wipe joint with rag or brush and see that joint is filled. Remove any discoloration of fitting or pipe, due to heat, by rubbing with steel wool.

Tubes as supplied by the maker must be capable without further heat treatment of being bent in a suitable bending machine round a radius equal to four times the diameter of the tube without filling and without collapse or deformation of the tubes. Each tube should be capable without further heat treatment of being bulged with a conical tool without showing either crack or flaw until the diameter of the bulged end shows an increase not less than the square root of the original cross-sectional area of the tube, e.g. ½-in. bore by 19 W.G. must give 52·5 per cent. expansion, and 1½-in. bore by 17 W.G. must give 35 per cent. expansion.

The tubes should be free from internal or external grooving, spills, laminations, or other defects. In other respects the tubes shall conform to the requirements of the British Admiralty and British Standard Specifications.

B.S. SPECIFICATION

Scope

This specification applies to light-gauge copper tubes suitable for connection by means of compression joints or capillary joints or by bronze welding, and for working water pressures up to 150 lb. per sq. in. (350 ft. head). The specification does not apply to redrawn used tubes.

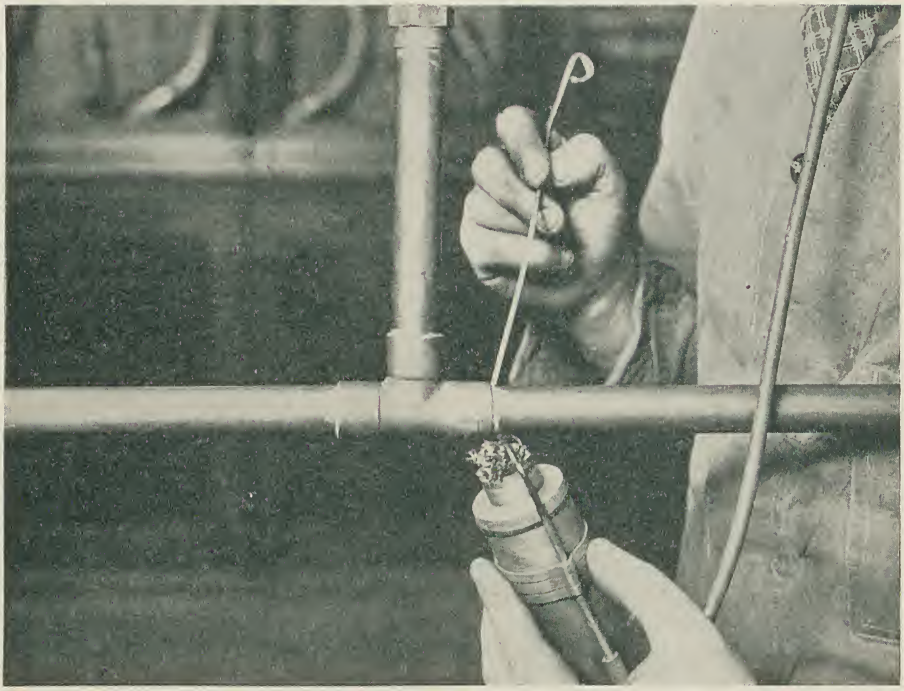


Fig. 13.—USING A MOUTH BLOW-PIPE FOR RUNNING THE SOLDER INTO A COPPER TEE JOINT

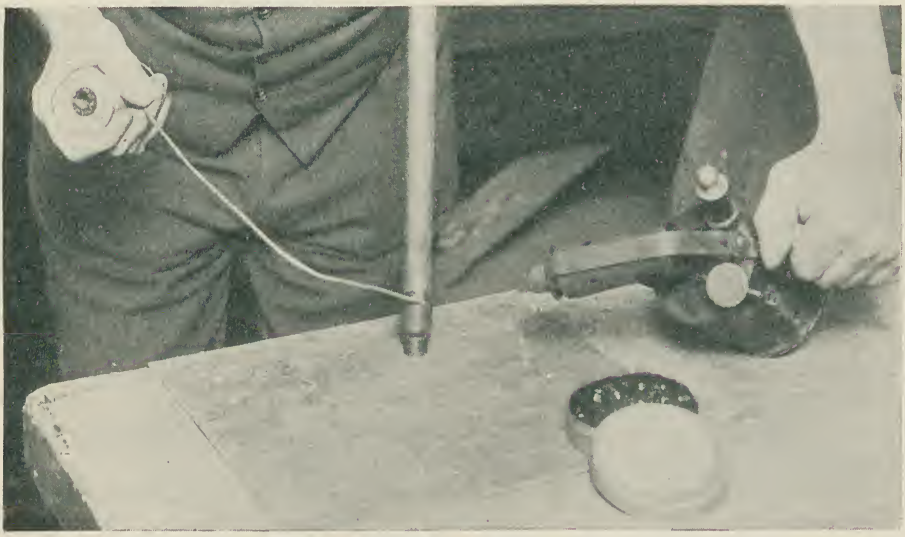


Fig. 14.—RUNNING THE SOLDER INTO COPPER JOINT, USING A BLOW-LAMP FOR APPLYING HEAT

Chemical Composition

The tubes shall be manufactured from virgin copper, to which may be added the tube manufacturer's own process scrap from similar material. The tube shall show on analysis a deoxidised copper of the following composition :—

Copper : not less than 99·20 per cent.

Arsenic : Not less than 0·3 per cent., nor more than 0·5 per cent.

Mechanical Tests on Copper

(*a*) **Drifting Test**

The tubes as supplied, without annealing, shall be capable of withstanding drifting, by means of a taper drift having an included angle of 30°, as shown in Fig. 1, without showing either crack or flaw, until the diameter of the drifted end measures at least 25 per cent. more than the original diameter of the tube.

(*b*) **Flattening and Doubling-over Test**

The tubes shall be capable of withstanding the following test, both cold and at a red heat, without showing crack or flaw. A piece of the tube, after annealing, shall be flattened down until the interior surfaces of the tube meet, as shown in Fig. 2, and then be doubled over on itself, that is, bent through an angle of 180°, the bend being at right angles to the direction of the length of the tube, as shown in Fig. 3.

Hydraulic Test

The tube shall be capable of withstanding a hydraulic test pressure of the amount given in the following Table without showing signs of leaking, weeping, or permanent increase in diameter :—

Bore of Tube	*Hydraulic Test Pressure*
In.	*Lb. per Sq. In.*
Up to and including 1¼	500
Above 1¼	300

APPROXIMATE WEIGHTS PER FOOT

Bore of Tube	*Thickness*	*Weight per Ft.*
In.	*S.W.G.*	*Lb.*
⅛	19	0·08
¼	18	0·17
⅜	18	0·25
½	18	0·32
¾	18	0·46
1	17	0·71
1¼	17	0·88
1½	17	1·05
2	16	1·60
2½	16	1·98
3	15	2·68
3½	14	3·46
4	13	4·55

SPECIFICATION

To B.E.S.A., No. 61–1913, FOR USE WITH SCREWED FITTINGS,

Nominal Bore	TABLE I. SUITABLE FOR SCREWED CONNECTIONS *Working Pressures up to 50 lb. per sq. in. or a Hydraulic Head of 120 ft.*					TABLE II. SUITABLE FOR SCREWED CONNECTIONS *Working Pressures up to 125 lb. per sq. in. or a Hydraulic Head of 300 ft.*				
	Outside Diam.	*Gauge*	*No. of Threads per in.*	*Length of Thread*	*Theoretical Weight per ft.*	*Outside Diam.*	*Gauge*	*No. of Threads per in.*	*Length of Thread*	*Theoretical Weight per ft.*
in.	*in.*			*in.*	*lb.*	*in.*			*in.*	*lb.*
$\frac{1}{8}$	·253	16	28	$\frac{5}{16}$	·15	·253	16	28	$\frac{5}{16}$	·15
$\frac{1}{4}$	·394	15	20	$\frac{3}{8}$	·28	·394	14	20	$\frac{3}{8}$	·29
$\frac{3}{8}$	·519	15	20	$\frac{1}{2}$	·39	·519	14	20	$\frac{1}{2}$	·41
$\frac{1}{2}$	·644	15	20	$\frac{1}{2}$	·50	·644	14	20	$\frac{1}{2}$	·53
$\frac{5}{8}$	·769	15	20	$\frac{5}{8}$	·61	·769	14	20	$\frac{5}{8}$	·67
$\frac{3}{4}$	·894	15	20	$\frac{5}{8}$	·72	·894	13	20	$\frac{5}{8}$	·89
$\frac{7}{8}$	1·019	15	20	$\frac{3}{4}$	·82	1·019	13	20	$\frac{3}{4}$	1·03
1	1·160	14	20	$\frac{3}{4}$	1·04	1·160	12	20	$\frac{3}{4}$	1·33
$1\frac{1}{8}$										
$1\frac{1}{4}$	1·410	14	20	$\frac{7}{8}$	1·29	1·410	12	20	$\frac{7}{8}$	1·64
$1\frac{3}{8}$										
$1\frac{1}{2}$	1·660	14	20	$\frac{7}{8}$	1·53	1·660	12	20	$\frac{7}{8}$	1·96
$1\frac{5}{8}$										
$1\frac{3}{4}$	1·934	13	16	1	2·05	1·934	12	16	1	2·30
$1\frac{7}{8}$										
2	2·184	13	16	1	2·33	2·184	12	16	1	2·61
$2\frac{1}{4}$	2·434	13	16	1	2·61	2·434	11	16	1	3·25
$2\frac{1}{2}$	2·684	13	16	1	2·88	2·684	11	16	1	3·60
$2\frac{3}{4}$	2·934	13	16	1	3·16	2·934	10	16	1	4·34
3	3·208	12	16	$1\frac{1}{8}$	3·90	3·208	10	16	$1\frac{1}{8}$	4·77
$3\frac{1}{4}$	3·458	12	16	$1\frac{1}{8}$	4·22	3·458	10	16	$1\frac{1}{8}$	5·16
$3\frac{1}{2}$	3·732	11	16	$1\frac{1}{8}$	5·07	3·732	9	16	$1\frac{1}{8}$	6·25
$3\frac{3}{4}$	3·982	11	16	$1\frac{1}{8}$	5·42	3·982	9	16	$1\frac{1}{8}$	6·68
4	4·256	10	16	$1\frac{1}{4}$	6·39	4·256	8	16	$1\frac{1}{4}$	7·93

Screwing specifications reprinted by permission of The British Engineering Standards Association.

OF COPPER TUBES

AND LIGHTER GAUGES FOR ANY TYPE OF FITTING (NOT SCREWED)

TABLE III.
SUITABLE FOR SCREWED CONNECTIONS
Working Pressures up to 200 lb. per sq. in.

Outside Diam.	*Gauge*	*No. of Threads per in.*	*Length of Thread*		*Theoretical Weight per ft.*
			On Pipe End Min.	*In Coupler Min.*	
in.			*in.*	*in.*	*lb.*
·388	14	28	$\frac{3}{8}$	$\frac{3}{4}$	·30
·523	13	19	$\frac{7}{16}$	$\frac{7}{8}$	·48
·661	13	19	$\frac{1}{2}$	1	·63
·830	12	14	$\frac{5}{8}$	$1\frac{1}{4}$	·91
·907	11	14	$\frac{5}{8}$	$1\frac{1}{4}$	1·11
1·046	11	14	$\frac{3}{4}$	$1\frac{1}{2}$	1·30
1·194	11	14	$\frac{3}{4}$	$1\frac{1}{2}$	1·51
1·314	10	11	$\frac{7}{8}$	$1\frac{3}{4}$	1·84
1·497	9	11	$\frac{7}{8}$	$1\frac{3}{4}$	2·36
1·655	9	11	1	2	2·63
1·750	9	11	1	2	2·80
1·887	9	11	1	2	3·04
2·087	9	11	$1\frac{1}{8}$	$2\frac{1}{4}$	3·38
2·121	9	11	$1\frac{1}{8}$	$2\frac{1}{4}$	3·44
2·249	9	11	$1\frac{1}{8}$	$2\frac{1}{4}$	3·67
2·352	9	11	$1\frac{1}{8}$	$2\frac{1}{4}$	3·85
2·592	8	11	$1\frac{1}{4}$	$2\frac{1}{2}$	4·71
2·965	7	11	$1\frac{1}{4}$	$2\frac{1}{2}$	5·94
3·215	7	11	$1\frac{3}{8}$	$2\frac{3}{4}$	6·47
3·465	6	11	$1\frac{3}{8}$	$2\frac{3}{4}$	7·60
3·705	6	11	$1\frac{1}{2}$	3	8·16
3·955	5	11	$1\frac{1}{2}$	3	9·60
4·205	5	11	$1\frac{1}{2}$	3	10·24
4·455	4	11	$1\frac{5}{8}$	$3\frac{1}{4}$	11·85

LIGHT-GAUGE TUBES.
FOR ANY TYPE OF FITTING
(not screwed)

Bore	*Gauge*	*Theoretical Weight per ft.*	*Hydraulic Bursting Pressure per sq. in.*
in.		*lb.*	*lb.*
$\frac{3}{8}$	19	·20	9000
$\frac{1}{2}$	18	·32	8100
	19	·26	6700
$\frac{3}{4}$	18	·46	5400
	19	·38	4500
1	17	·71	4700
	18	·61	4100
	19	·50	3400
$1\frac{1}{4}$	17	·88	3800
	18	·75	3200
$1\frac{1}{2}$	17	1·05	3200
	18	·90	2700
2	16	1·60	2700
	17	1·39	2400
$2\frac{1}{2}$	16	1·98	2200
	17	1·73	1900
3	15	2·68	2000
	16	2·37	1800
$3\frac{1}{2}$	14	3·46	1900
	15	3·11	1700
4	13	4·55	1900
	14	3·95	1700

By courtesy of the Yorkshire Copper Works Ltd., Leeds.

Jointing

The question as to which is the best method of jointing light-gauge tubing is one that has given rise to much argument. Various methods may now be adopted, and one has the choice of using—

(1) Compression joints.
(2) The "Ideal" joint.
(3) Welding.
(4) Brazing.
(5) The "Yorkshire" capillary joint.

Compression Joints

There is a wide choice of compression joints, and to describe each type would require too much space here. They may be divided into manipulative and non-manipulative joints. The manipulative types are those in which the tube requires preparation by expanding the ends so as to correspond with the fitting used, and this is done by a special steel mandrel shaped to correspond with the taper of the fitting, or by enclosing the tube end in a specially shaped small clamp and expanding it by means of small steel tools. The non-manipulative type simply requires the end of the tube to be cut square before assembling the joint. The preparation and assembly of any of the various types is not a difficult matter, and whether of the manipulative or non-manipulative pattern, very few tools are required to make them.

The "Ideal" Joint

This joint is formed by the use of a wrought-copper fitting, into which the tube is slipped. The ends of the tubes and the interior of the "sockets" of the fitting are cleaned with steel wool or sandpaper, smeared with flux, and the tubes slipped into the fitting. Heat is applied by means of a blow-lamp, and soft solder is melted into the joint. These fittings permit of an unrestricted flow, are rust-proof and corrosion resisting, and are made so that a push-in fit is maintained between the fitting and the tube. As these fittings are of copper they have the same specific heat as the tube itself and therefore heat and cool uniformly, and, owing to the quick heat-disseminating powers of copper, the solder sets almost immediately after the removal of heat when making the joint. A very small quantity of solder is required to make the joint, and the tin of the solder penetrates to some extent the surface of the tube and the fitting, thus forming a perfect bond. Very few tools are required for making this type of joint.

Welding

The welding of joints has been adopted on many contracts, and the system has much to commend it, as fittings (which in the main are an expensive item in copper installations) are dispensed with. Branches

may be formed in lengths of tube as and where required, and special branch pieces and similar fittings may be made up from tubing and the seams welded. This is a very useful and economical asset, especially where awkward jobs, entailing the use of special fittings, have to be overcome, as they can be made up much easier and cheaper than would be the case if they were ordered specially, in addition to the saving in time. The "Sifbronze" process is used extensively for joining light-gauge copper tubing. The objection sometimes raised to the welding process is that it requires the services of a trained man, and the necessary outfit for the purpose. This is, of course, expensive in initial cost when compared with the few tools necessary for making compression or solder type joints, but the plant may be put to many other uses, and the saving in fittings would soon repay the cost of equipment.

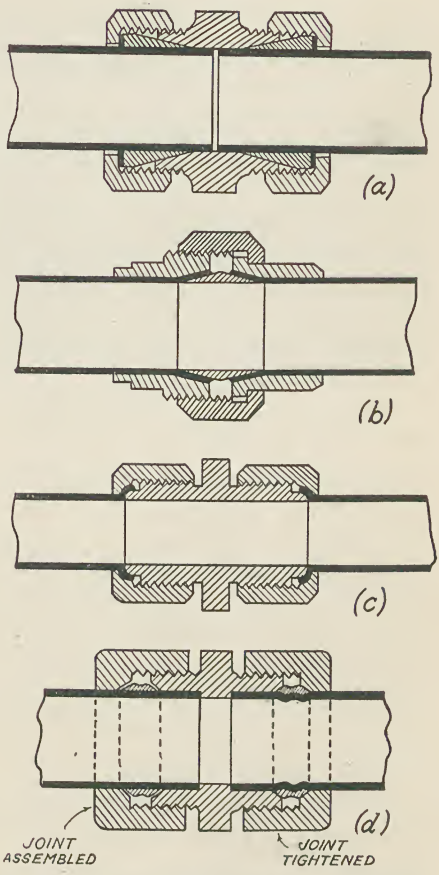


Fig. 15.—FOUR PATTERNS OF COMPRESSION JOINT FOR COPPER TUBING

(*a*) The "Kontite" joint; (*b*) "Securex" joint; (*c*) "D.D." joint; (*d*) "Instantor" joint (*Copper Development Association*)

Brazing

This is a process which may be applied by the use of a welding blow-pipe. A brazing alloy, "Silfos," consisting mainly of copper with small additions of silver and phosphorus, is used, and which has a melting-point much lower than brazing or welding material.

The Capillary Joint

The "Yorkshire" capillary joint is formed by using a hot-pressed brass fitting in which is incorporated a ring of solder secured in a groove within the fitting. To make the joint, the ends of the tube and the interior of the fitting are cleaned with steel wool or sandpaper, smeared with flux, and slipped together. Heat is applied to the joint by means of a blow-lamp and maintained until the solder from the groove appears at the neck of the fitting; the solder passes to the top and bottom of the

Fig. 16.—MAKING THE "KONTITE" COMPRESSION JOINT

Note the tapered nipple being inserted into the fitting. The coupling nut is then screwed up over the nipple, tight on to the fitting.

socket portion of the fitting by capillarity, forming a perfect joint between the fitting and the tube, the solder penetrating the surface of the metal in each case. Overheating does not impair the joint, and neither does any solder find its way into the pipe through this cause. The joints may be made in any position, and very few tools are required other than those normally carried by the plumber or fitter. This type of joint is becoming popular for both water and waste pipes. The space between tube and fitting is a matter of thousandths of an inch, so that the amount of solder required is very small.

Tests on Capillary Joints

It may be of interest to give here the results of tests which the writer carried out with "Yorkshire" capillary joints and tubes. The

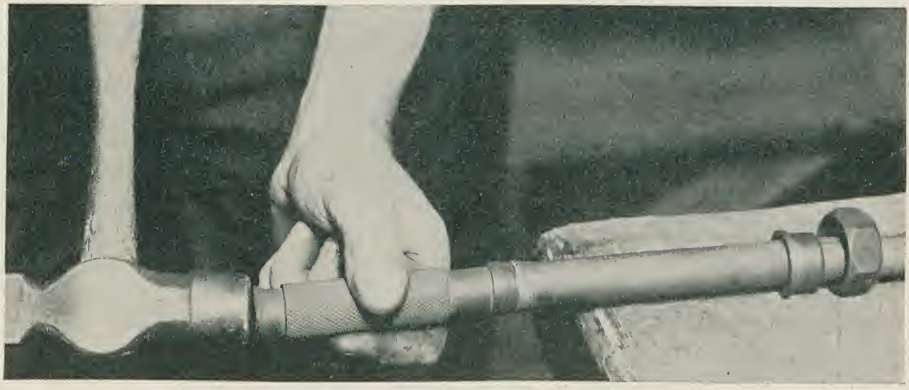


Fig. 17.—MAKING THE "SECUREX" JOINT

This shows the first operation—belling out the copper tube for the joint with special steel mandrel.

Fig. 18.—ASSEMBLING THE "SECUREX" COMPRESSION JOINT

Tapered cone piece being inserted in centre to fit between the belled-out ends of the two pipes. The nut is then screwed up tight.

joints in tests (*a*) and (*b*) were prepared and made by him, and that in test (*c*) in his presence.

(*a*) Bursting Test on Remade Joint

A joint was made in the usual manner with a standard No. 1 straight coupling and two short pieces of standard "Yorkshire" housing tube. After the joint was completed and had been cooled it was reheated, and both tubes were withdrawn from the coupling. The joint was then remade by inserting the tinned ends of the tubing into the coupling and applying heat until the ring of solder was continuous around the mouths of the coupling, as in the first instance. The joint was then tested by internal hydraulic pressure until a pressure of 5,600 lb. per sq. in. was reached, when one of the pieces of tube burst. This is the normal bursting

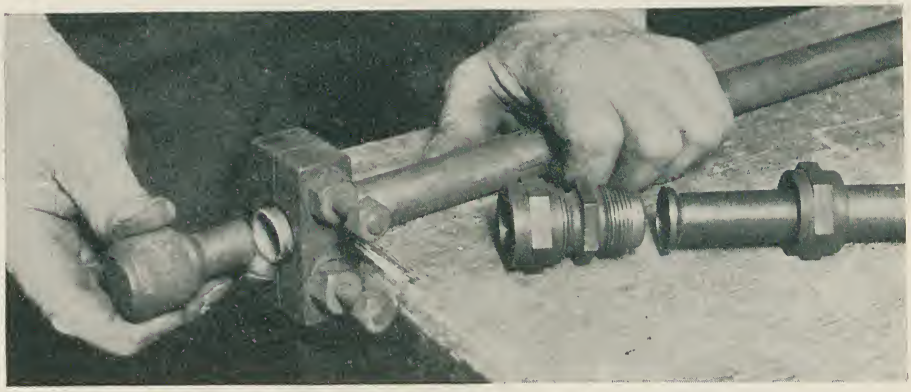


Fig. 19.—PREPARING THE TUBE FOR THE "D.D." COMPRESSION JOINT

A complete assembly for the "D.D." joint is shown on the right.

Fig. 20.—ASSEMBLING THE "INSTANTOR" JOINT
Note the special ring which is slipped on to the tube. The nut is tightened over this.

pressure of ¾-in. bore 19 W.G. "Yorkshire" housing tube. The "Yorkshire" joint was absolutely sound throughout and at the conclusion of the test.

(*b*) **Tensile Test**

A joint was made in the normal manner with a No. 1 straight coupling and two pieces of standard "Yorkshire" housing tube ¾-in. bore by 19 W.G. The joint was then placed in a tensile testing machine, and tensile pull was applied at the end of each tube away from the joint in an endeavour to pull the tubes out of the fitting. Copper housing tubes usually have a tensile strength of approximately 42,560 to 44,800 lb. per sq. in., but a joint made with a "Yorkshire" fitting is even stronger than the tube. Actually, one of the two pieces of tube in this test fractured at a point away from the joint at 49,168 lb. per sq. in. The joint was perfectly sound at the conclusion of the test.

(*c*) **Overheating Test**

A standard stop or cap, after being joined to a piece of tube and the appearance of the ring of solder (which is proof of a sound joint), has the heat from a blow-lamp applied until the metal of the fitting commences to melt and run. The joint was tested and found to be quite sound at an internal hydrostatic pressure of between 1,000 and 1,250 lb. per sq. in. The joint was then sectioned and efforts were made to pull the tube away from the fitting, but it was impossible to do this completely, the tube itself tore apart without leaving the fitting. This test proved that it is impossible to affect the strength of a "Yorkshire" joint by overheating even to the extent of raising it to melting-point. The solder does not leave the joint when excessive heat is applied.

Comparison with Other Metals

From the foregoing it would appear that the chief advantages of light-gauge copper tube over that of other metals are :—

(1) The neat design of the latest types of fittings, together with the thinner wall thickness of the tubes, gives a neat and improved appearance to the finished work.

(2) The ease and speed with which joints are made and the minimum kit of tools required.

(3) Cutting and screwing gear is not required.

(4) The time saved in fixing due to easy handling.

(5) The saving of joints where good use is made of the bending machine.

(6) Low maintenance costs due to absence of corrosion.

SHEET COPPER

The description sheet is generally applied to material which is over 15 in. wide and cut to exact lengths ; the thickness varies from $\frac{3}{8}$ in. down to 0·01 in. The dimensions for width and length may be varied within wide limits, and may be up to 4 ft. wide by 12 ft. long or longer according to requirements. As the thickness decreases it becomes difficult to produce sheets of great width.

Roofing

For roofing purposes, the gauge varies according to requirements, but for the general run of roofing work it varies from 20 to 24 gauge. The sizes of the sheets in general use are 6 ft. by 2 ft., 5 ft. 3 in. by 2 ft. 8 in., and 4 ft. by 3 ft. 6 in. These sheets are rolled from " cakes " of copper which vary from 150 lb. to 1,000 lb. in weight.

TABLE II

WEIGHT AND THICKNESS OF SHEET COPPER FROM 20 TO 30 GAUGE

Size of Sheet	*Gauge*	*Thickness in In.*	*Weight per Sq. Ft. in Oz.*	*Weight of Sheet in Lb.*
5 ft. 3 in. by 2 ft. 8 in.	20	0·0352	28	24½
5 ft. 3 in. by 2 ft. 8 in.	22	0·0275	22	18
5 ft. 3 in. by 2 ft. 8 in.	24	0·0195	16	14
5 ft. 3 in. by 2 ft. 8 in.	26	0·0156	12	11¼
5 ft. 3 in. by 2 ft. 8 in.	28	0·0142	10	8¾
5 ft. 3 in. by 2 ft. 8 in.	30	0·0117	8	7

As a roof covering, copper can be said to possess many advantages over other materials. Compared with lead it is much lighter ; a square foot of 22 gauge copper weighs 1 lb. 6 oz., and a square foot of sheet lead suitable for ordinary roofing work must be at least of 5 lb. or 6 lb. substance: quite a substantial difference in weight and incidentally in cost. Copper is fireproof and will not collapse under great heat, whereas lead is easily melted. Owing to the light nature of copper it does not require the same type of support, and it does not creep from position when fixed to steep slopes.

TABLE III

COMPARATIVE STRENGTH OF LEAD AND COPPER TUBES TO RESIST CRUSHING LOADS

Size	*Material*	*Thickness*	*Lb. per yard*	*Limiting Elastic Load. Lb. per ft. run*	*Complete Collapsing Pressure. Lb. per sq. in. Copper only*
		Gauge In.			
½ in.	Copper . .	18 = 0·048	0·96	3,200	5,400
	Lead . .	0·19	6·0	2,400	—
¾ in.	Copper . .	18 = 0·048	1·38	2,140	3,400
	Lead . .	0·20	9·0	1,600	—
1 in.	Copper . .	17 = 0·056	2·13	1,870	2,700
	Lead . .	0·21	12·0	1,400	—

Adaptability

Copper does not lend itself to the same manipulation as sheet lead, and it cannot be shaped to fit any position in the same manner as lead. The class of copper used is " dead soft," and although of this nature very little can be done in the way of shaping without the introduction of " gussets," " welts," and " clinking." Copper can be " shrunk " or stretched to a certain extent, but not sufficiently to form certain pieces for roof covering without the use of a gusset piece, whereas lead can be made to " travel " by the process of bossing.

Weather-resisting Qualities

Copper possesses excellent weather-resisting qualities, and is not affected by atmospheric influences. It is noted for the " patina " which develops after exposure to the atmosphere.

Later articles will deal with the application of copper pipes and tubes to specific purposes in the equipment of buildings.

BUILDING A HOUSE

SHOWING THE VARIOUS OPERATIONS STAGE BY STAGE

Fig. 1.—The completed house, showing the front entrance
(*Architect: J. C. Rogers, A.R.I.B.A., St. Albans*)

THE series of photographs which appear in the following pages are intended to show, stage by stage, the various operations in the erection of a small detached house.

They give a very clear idea of the stages by which the work progresses, from the excavation of the original site to the fixing of the roof, and the final operations inside the house itself. In addition to the photographs showing various details in the erection of the house, there are several pictures showing the appearance of the house at various stages of the work,

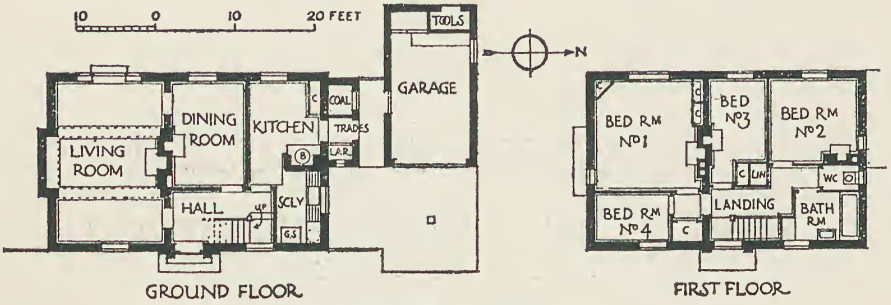


Fig. 1A.—THE PLANS: NOTE THE LARGE LIVING-ROOM, AND COMPACT ARRANGEMENT OF DINING-ROOM AND KITCHEN QUARTERS (*Architect: J. C. Rogers, A.R.I.B.A., St. Albans*)

i.e. when the first scaffolding is erected, when the work is up to first-floor level, and so on.

A glance at the plan which appears will show that there is not an inch of waste space, a very desirable feature of the modern house. The house was designed by Mr. John C. Rogers, A.R.I.B.A., and erected at St. Albans. There is an absolute minimum of passage space, and at the same time convenient access is given to every room, and the hall and staircase are compactly devised.

Fig. 2.—THE ORIGINAL SITE

Fig. 3.—REMOVING THE TURF AND TOP SPIT

Which was wheeled to a dump to form the basis of a rockery at the bottom of the garden.

Fig. 4.—SETTING OUT THE SITE

Using horses, lines, and pegs. Practical notes on the method of setting out will be found on pages 76–80.

Fig. 5.—TESTING THE FLOOR LEVEL WITH STRAIGHT-EDGE AND SPIRIT-LEVEL AFTER THE TRENCHES HAVE BEEN EXCAVATED

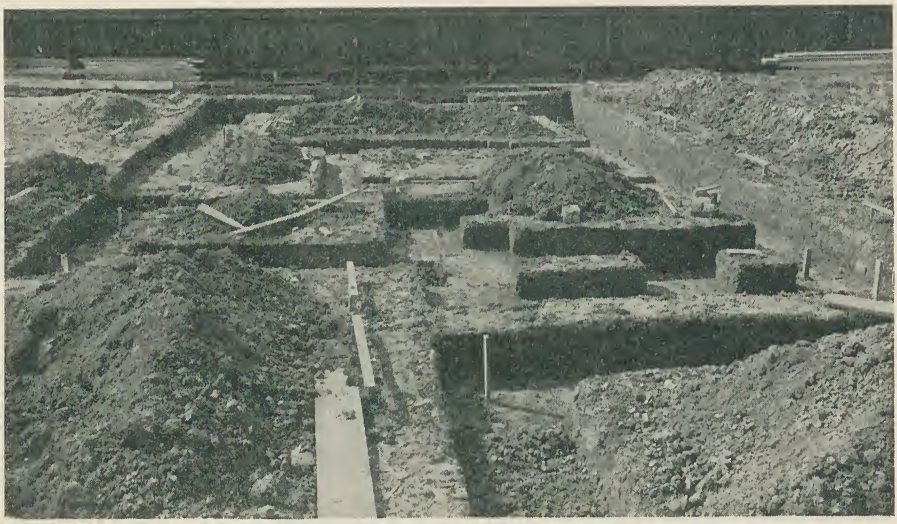


Fig. 6.—THE PLAN OF THE WALLS CUT IN THE EARTH, AND THE TRENCHES READY FOR THE CONCRETE; THE PEGS ARE DRIVEN IN TO FORM A GUIDE FOR THE THICKNESS OF CONCRETE, IN THIS CASE 12 IN. THICK

This is only a small house with four bedrooms, but the wise plan has been adopted of getting one good-sized living-room (21 ft. by 14 ft.) with a small room for meals adjoining the kitchen.

The walls are of 11-in. hollow brickwork, with a cement face and final coating of "Atlas White," the plinth being tarred.

The roof is covered with red Bridgwater tiles of double Roman type, which do not require pins to secure them. The windows are steel casements in wood frames.

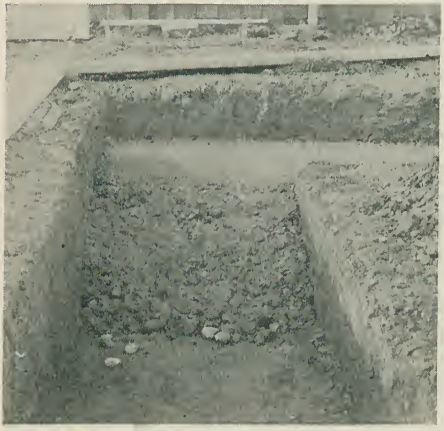


Fig. 7.—FORMING THE CONCRETE FOUNDATIONS, 12 IN. THICK, TO WALLS

Fig. 8.—THE CONCRETE UNDER THE SOUTH WALL OF THE LIVING-ROOM

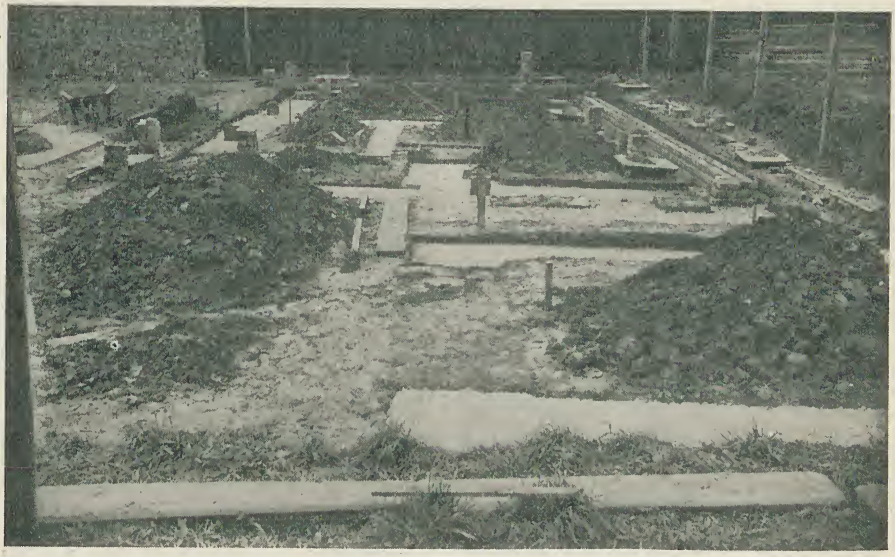


Fig. 9.—THE TRENCHES FILLED IN WITH 1 FT. OF CEMENT CONCRETE, WHICH FORMS THE SOLID FOUNDATIONS ON WHICH THE WALLS ARE BUILT

The front elevation is well proportioned, and the entry is marked by a slight projection which embraces the front door and the staircase window above it. The door is an unpanelled one, and the hood above it is carried by two fine old carved brackets of the Queen Anne period, as can be seen in Fig. 1.

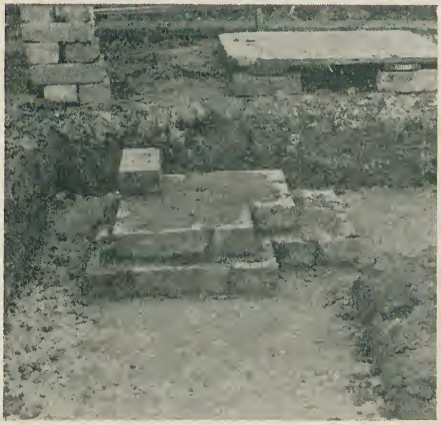


Fig. 10.—THE FIRST OPERATION IN BUILDING THE BRICK FOUNDATIONS IS TO LAY THE BRICKS AT THE ANGLES, AS SHOWN IN THE ABOVE ILLUSTRATION

Fig. 11.—THE START OF THE CENTRAL CAVITY: NOTE THAT THERE ARE TWO FOOTING COURSES, EACH OF WHICH PROJECTS 2¼ IN. BEYOND THE COURSE ABOVE

Fig. 12.—TESTING ANGLES WITH THE BUILDER'S SQUARE

The details of brickwork, including standard forms of bonding, will be found in Volume II.

Fig. 13.—A STAGE IN THE ERECTION OF THE BRICKWORK

A line is shown stretched from end to end of the wall to ensure the bricks being laid straight and true.

The eaves are brought well forward, giving a good shadow line, and along the soffit are spaced pairs of slender brackets.

It will be seen that a garage has been incorporated in the scheme as a one-storey wing, with a washing space in front of it, and a covered way

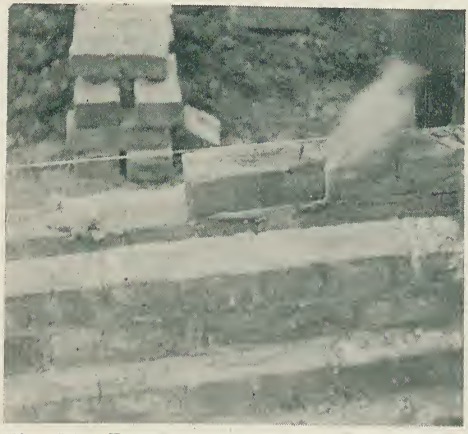


Fig. 14.—BUILDING THE 11-IN. CAVITY WALL. THE STRING, OR "LINE," TO WHICH THE BRICKS ARE LAID IS FIXED BY TWO "PINS" (METAL PEGS) HELD IN THE JOINTS OF THE BRICKS FIRST LAID AT THE WALL CORNERS

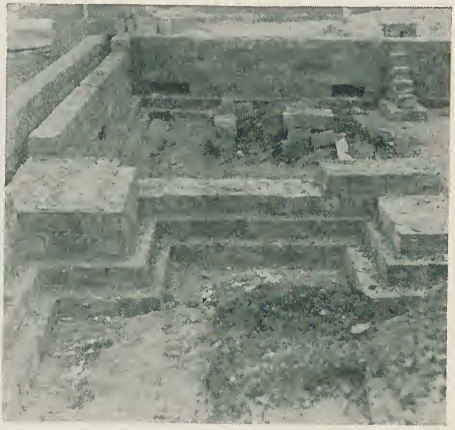


Fig. 15.—THE FOUNDATIONS FOR THE KITCHEN CHIMNEY: NOTE THE "RACKING BACK" FOR STARTING THE HALF-BRICK WALL IN THE TOP RIGHT-HAND CORNER

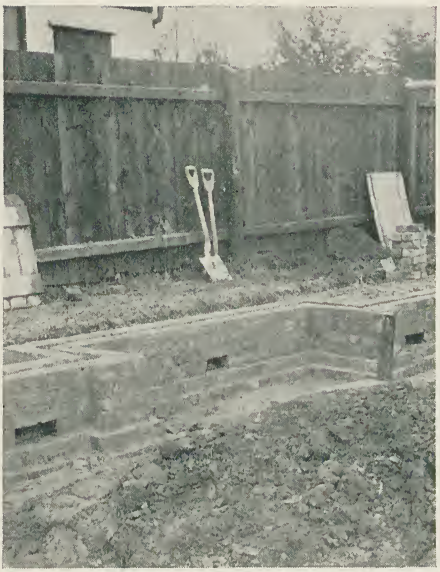


Fig. 16.—THE SOUTH WALL OF THE LIVING-ROOM SIX COURSES UP

Th terra-cotta air bricks inserted at intervals for under-floor ventilation are shown in Fig. 21.

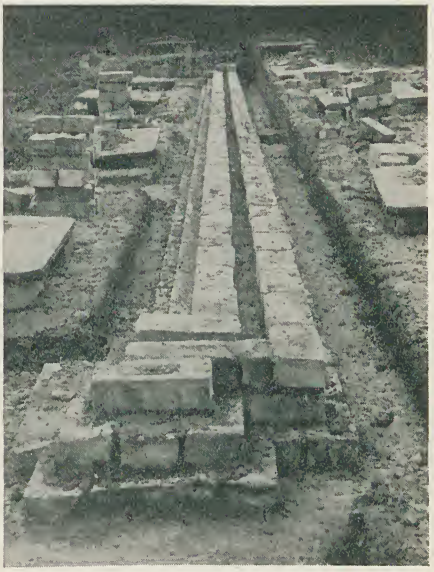


Fig. 17.—THE FOUNDATIONS OF THE WEST WALL

This photograph gives a clear view of the central cavity. For position of wall ties see Fig. 24.

leading through to the garden, and also giving access to the tradesmen's entrance.

During the process of construction some hundreds of photographs

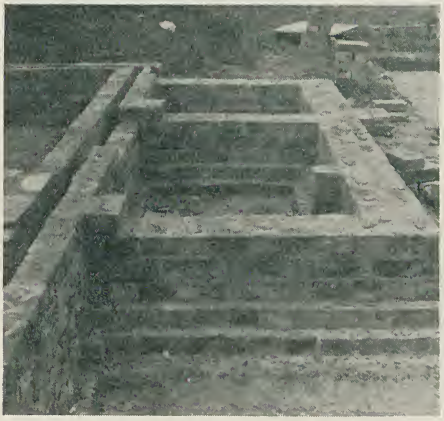


Fig. 18.—THE COALS AND LARDER ADDITION ON THE NORTH WALL

It will be seen that this is built on to the outer skin of the cavity walls. Fig. 22 shows the wall plan completed.

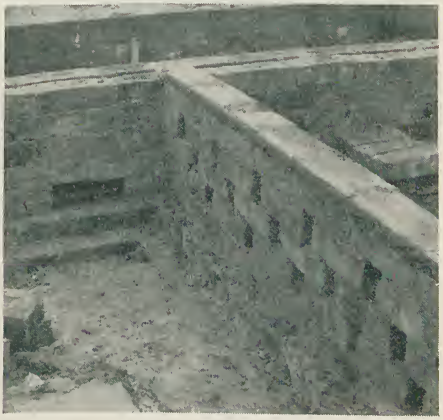


Fig. 19.—UP TO THE SLATE DAMP-COURSE

Showing a junction between an inner wall and the outer wall. Notice the honeycomb interior walls provided to give ventilation under the floors.

Fig. 20.—THE SLATE DAMP-PROOF COURSE IN CROSS-WALL WITH FIREPLACES

The double slate damp-course is laid in all walls just below ground-floor level.

Fig. 21.—TERRA-COTTA AIR BRICK, WITH DUCT ACROSS CAVITY, TO VENTILATE UNDERNEATH THE FLOOR AND THUS PREVENT DRY ROT

were taken. From these we have selected close on 100 to illustrate essential points.

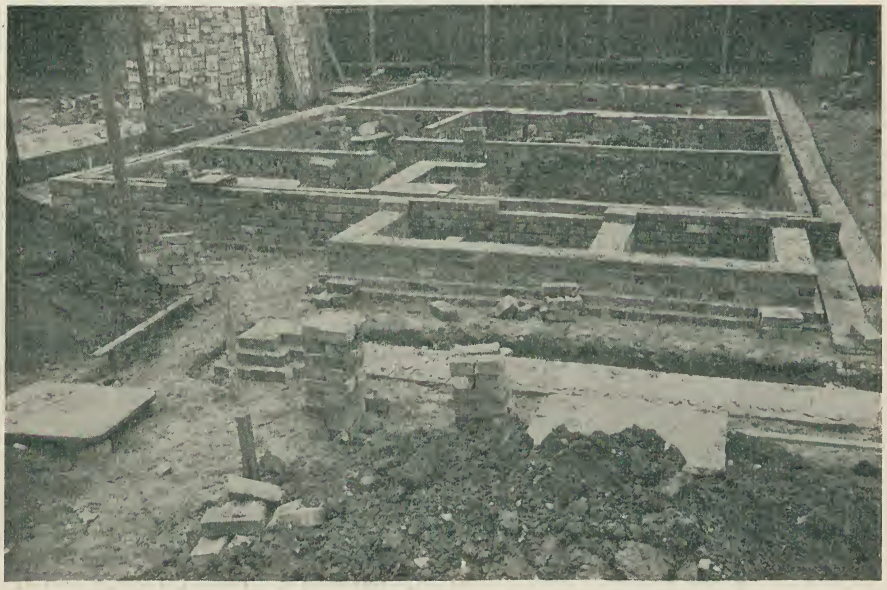


Fig. 22.—ALL THE WALLS OF THE HOUSE UP TO THE DAMP-PROOF COURSE

Yellow stock bricks have been used for the work up to this stage.

Fig. 23.—MAKING A START WITH FLETTON BRICKS ABOVE THE DAMP-PROOF COURSE

This shows how the work is started at one of the corners of the wall.

Fig. 24.—THE GALVANISED-IRON WALL TIES

These are placed every four or five courses in height. The central twist prevents water making its way from the outside half-brick skin to the inner skin.

The interior of the house has been well finished and equipped. The floors are of deal boards in narrow widths. The door and window furniture is in bronze, and the window cills are laid with tiles, waxed.

Fig. 25.—INTERIOR VIEW OF AIR BRICK

The lower cavity is an access hole for clearing mortar droppings from the cavity; it is filled in later.

Fig. 26.—THE NORTH-WEST ANGLE

Showing indents for bonding wall of the coal shed.

Fig. 27.—THE BRICKWORK RISING TO THE FIRST SCAFFOLD

Fig 28.—SPACE LEFT FOR AN INTERNAL DOORWAY

Note breeze blocks inserted for fixing door frames.

Fig. 29.—THE DOOR FRAMES IN PASSAGE BEING BUILT IN

The frames are held in a vertical position by wooden struts.

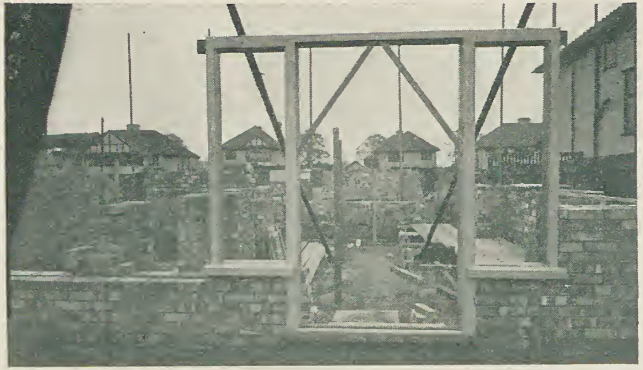


Fig. 30.—THE FRAME FOR THE FRENCH CASEMENTS AT THE WEST END OF THE LIVING-ROOM

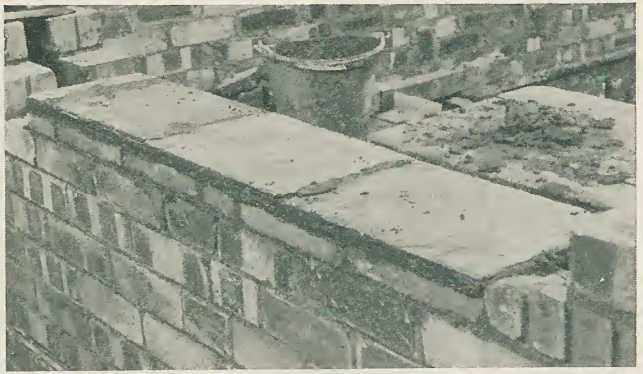


Fig. 31.—THE SLATE BED FOR WINDOW CILLS—A WISE BUT OFT NEGLECTED PRECAUTION

Fig. 32.—JAMB WITH BREEZE FIXING BRICK

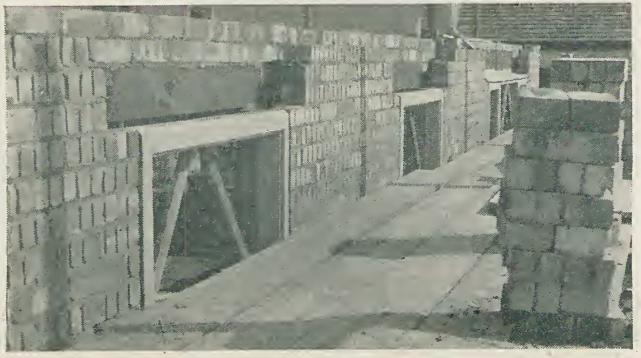


Fig. 33.—INNER LINTELS OVER GROUND-FLOOR WINDOWS

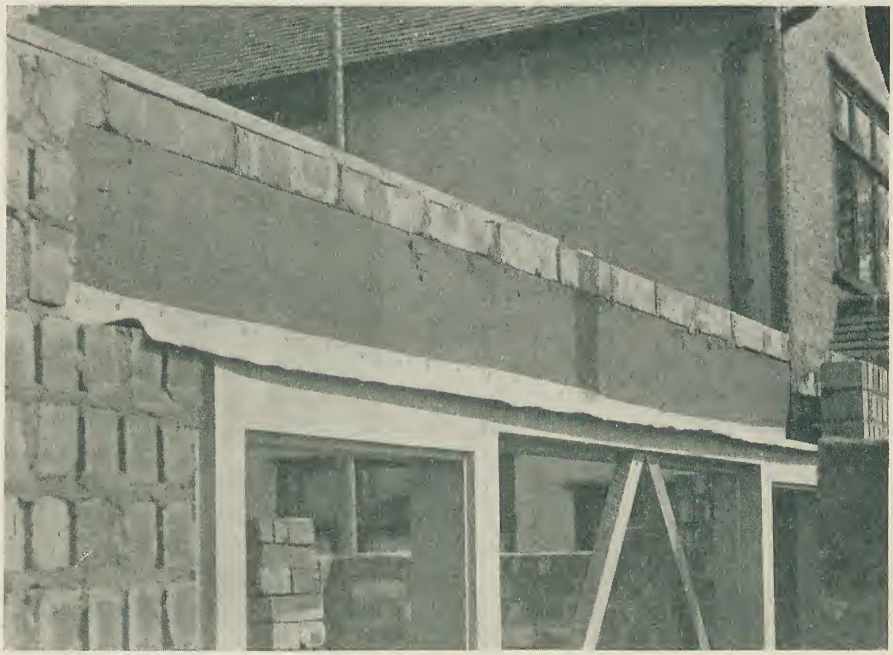


Fig. 34.—THE INNER WOOD LINTEL WITH LEAD IN POSITION READY TO RECEIVE THE OUTER CONCRETE LINTEL

This is to protect the head of a window frame in an external wall of cavity construction.

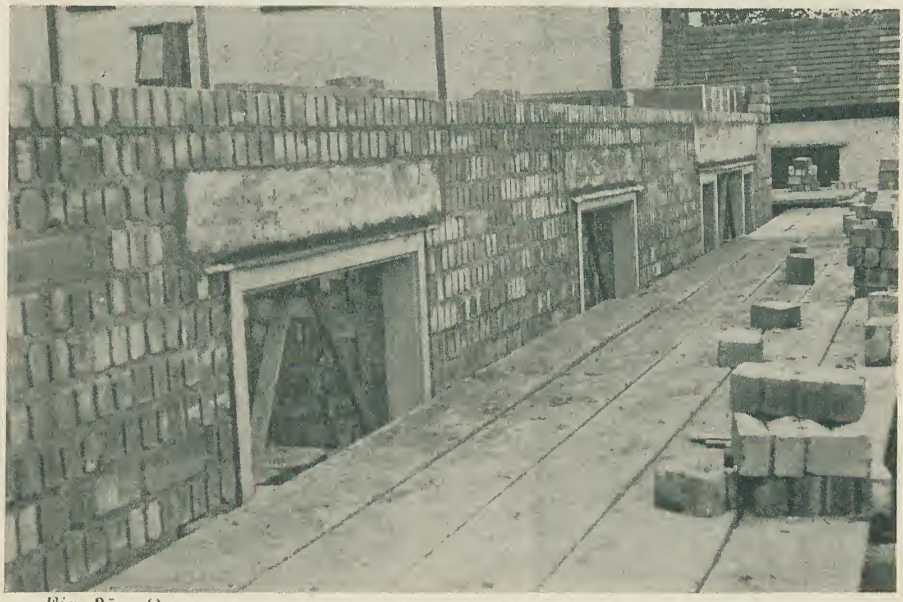


Fig. 35.—OUTER CONCRETE LINTELS WITH LEAD DRESSED OVER WINDOW HEADS

Fig. 36.—A STAGE IN THE ERECTION OF THE STACK OF FLUES

Fig. 37.—THE FIREPLACE LINTELS BEING CAST

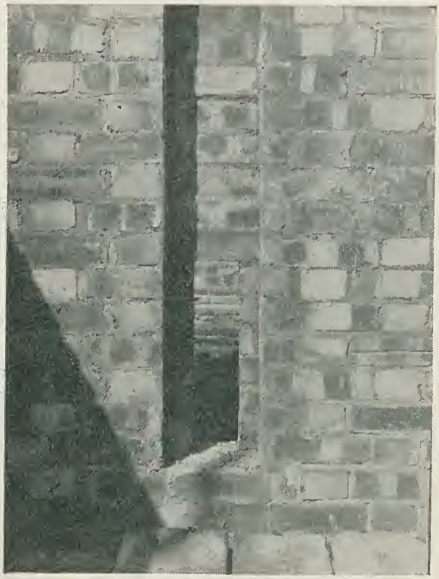


Fig. 38.—RECESS AND APERTURE FOR BOILER PIPES

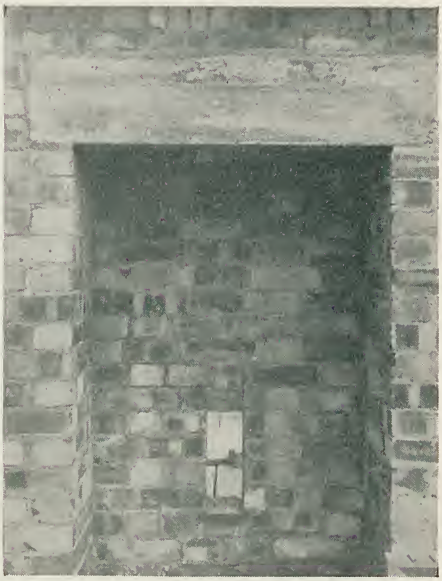


Fig. 39.—THE CONCRETE LINTEL OVER THE BOILER RECESS

The subject of hot-water supply and the central heating of domestic and other types of buildings is dealt with in Volume IV under the appropriate sections.

The lintel is splayed at the back in order to improve the updraught for carrying away hot air or fumes. Fig. 40 below shows the lintel reversed.

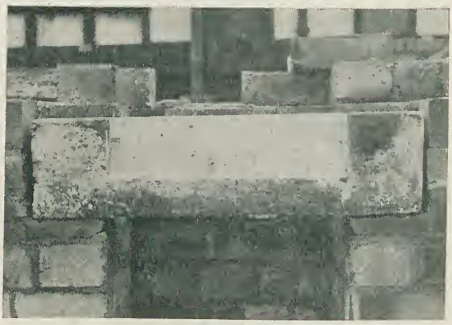


Fig. 40.—THE LINTEL INVERTED TO SHOW SPLAY

Fig. 41.—THE BEARING OF THE BEAM OVER THE LIVING-ROOM

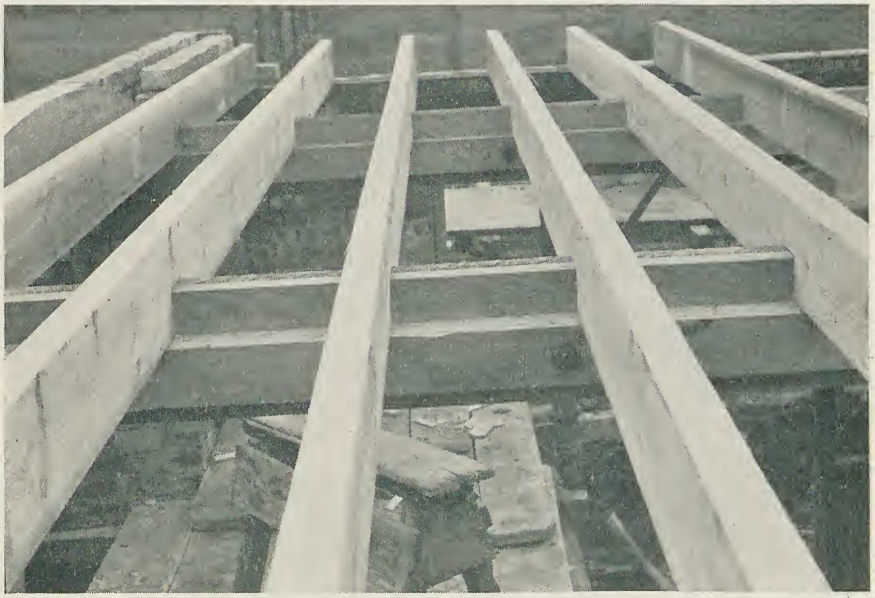


Fig. 42.—BEAMS AND JOISTS OVER THE LIVING-ROOM FORMING THE STRUCTURE OF THE BEDROOM FLOOR.

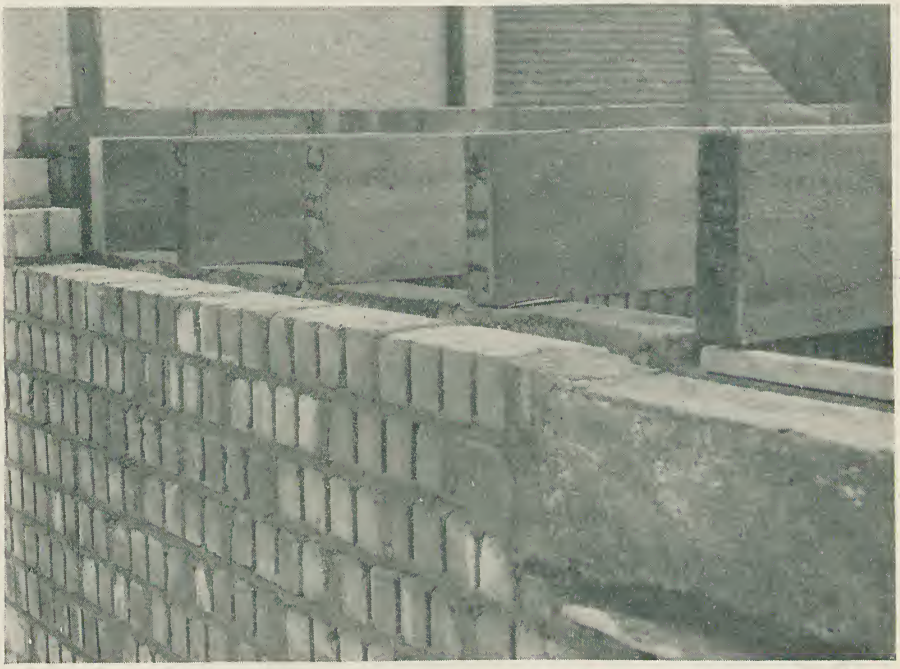


Fig. 43.—JOIST ENDS BEARING ON THE INNER 4½ IN. OF 11-IN. WALL

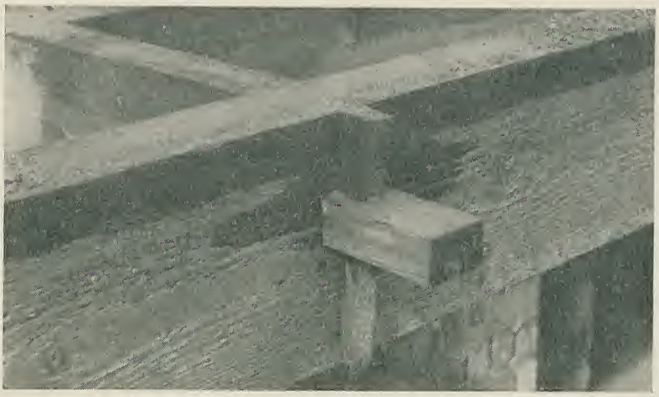


Fig. 44. — TUSK-TENON JOINT IN FIRST-FLOOR TIMBERS

Fig. 45.—THE EXTERNAL WALL AT THE FIRST-FLOOR LEVEL

Showing brick filling between the joist ends. The joists must not protrude into the cavity.

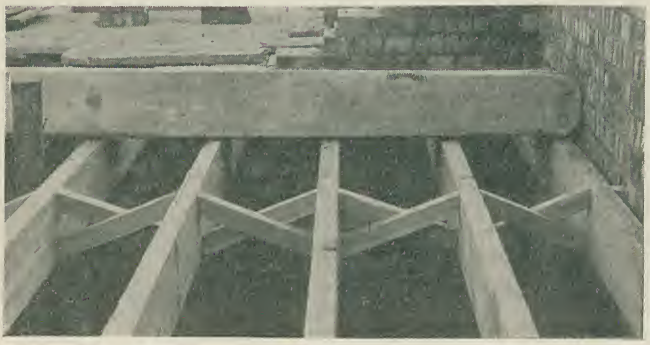


Fig. 46.—THE HERRINGBONE STRUTTING BETWEEN THE FIRST-FLOOR JOISTS

A method of stiffening the floor structure.

BUILDING A HOUSE

PART II.—FROM HALF-WAY UP TO COMPLETION OF THE HOUSE

IN the previous section in this volume we showed the various stages in the building of a small modern house, from the excavation of the site to the completion of walls up to first-floor level. We now continue the series of illustrations from this stage to the completion of the house. We show here some of the more important operations involved in the erection of the roof and roofing, the fixing of pipes, plastering, window frames, etc. These photographs are intended to give a clear idea of the various stages in which the building of a house is completed—no attempt has been made to show every operation in detail. Separate articles dealing thoroughly with each operation will be found under the appropriate headings.

Fig. 47.—THE WALLS HALF-WAY UP

It will be seen that all the ground-floor window frames and door frames are in position. The lintels over the frames can be clearly seen.

Fig. 48.—SETTING THE CEILING JOISTS (RIGHT) AND ROOF PLATE (LEFT)

The latter is often called the "wall plate," and it supports the feet of the rafters. It can be seen on the extreme left of the above photograph.

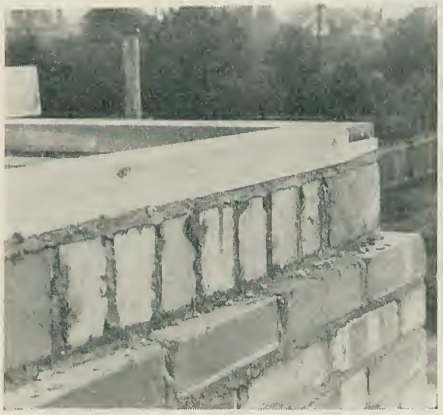


Fig. 49.—THE ROOF PLATES AT AN ANGLE, WHERE THE TWO PLATES ARE HALVED TOGETHER

Fig. 50.—THE ABOVE PHOTOGRAPH SHOWS THE WORK READY FOR THE ROOF RAFTERS

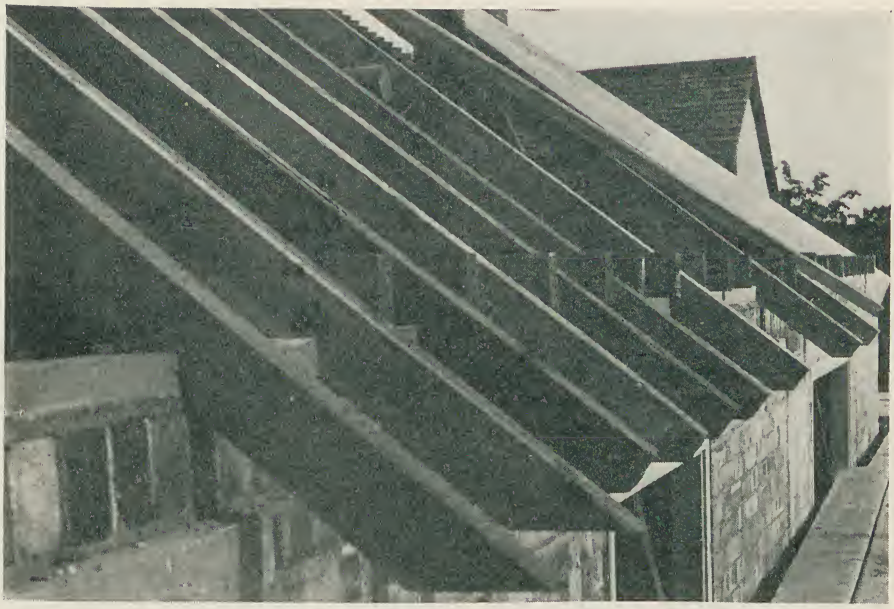


Fig. 51.—THE RAFTER FEET NOTCHED OVER THE PLATE

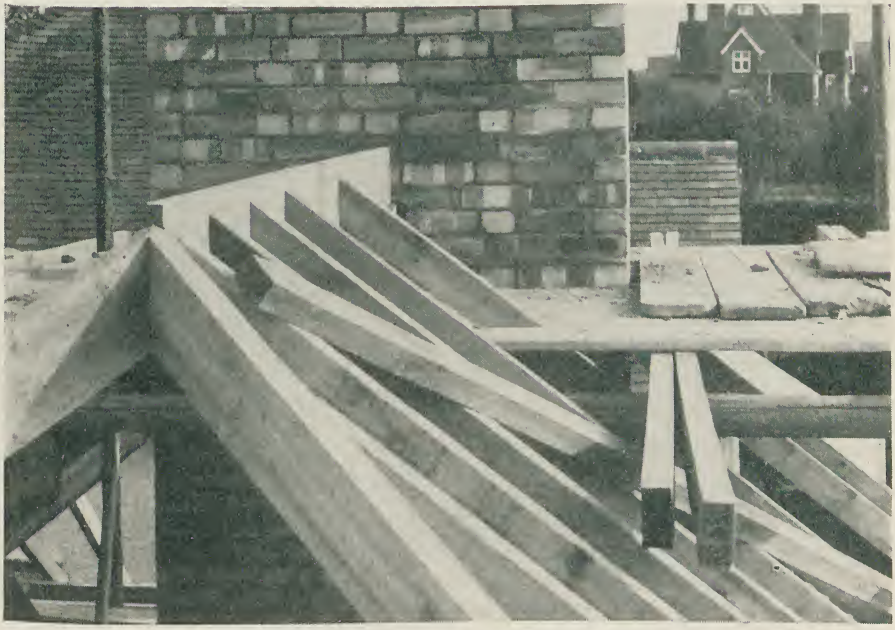


Fig. 52.—THE RIDGE AND CHIMNEY STACK

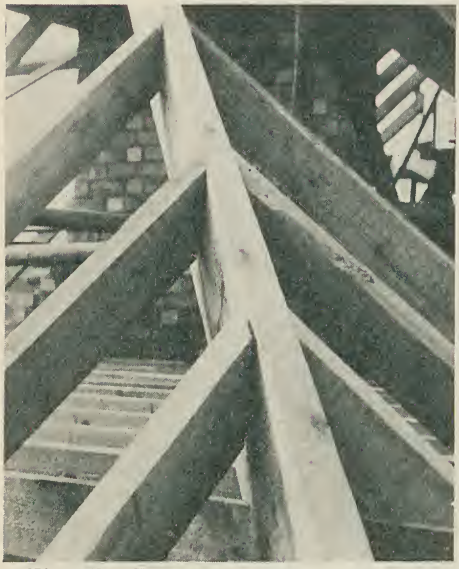


Fig. 53.—RAFTER JUNCTIONS WITH HIP RAFTER

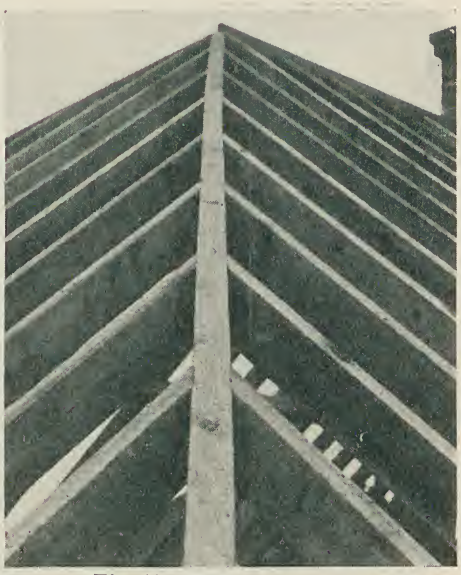


Fig. 54.—THE GARAGE ROOF
Showing the construction of the hip

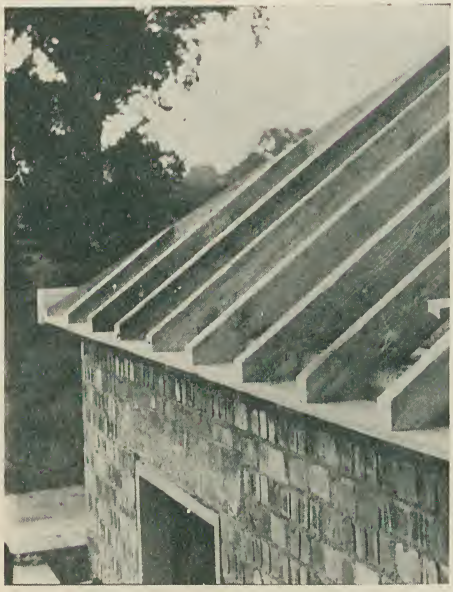


Fig. 55.—THE GARAGE ROOF

Note how ends of rafters are cut off to take the soffit board. The facia board is fixed to the front cut portion of the rafters.

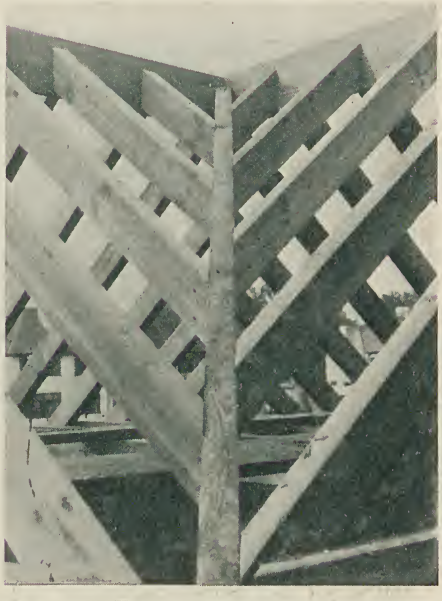


Fig. 56.—THE PHOTOGRAPH REPRODUCED ABOVE WAS TAKEN LOOKING UP THE VALLEY OF THE GARAGE ROOF

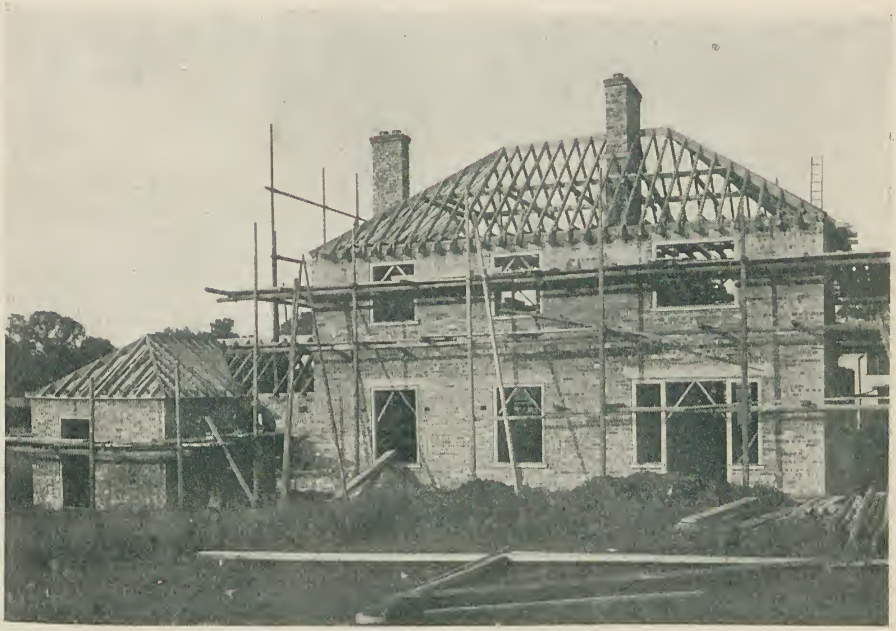


Fig. 57.—THE ROOFS READY FOR FELT AND TILES

Fig. 58.—FELTING THE ROOF: THE FELT IS SECURED WITH $\frac{3}{4}$″ FLAT-HEADED GALVANISED NAILS, CALLED CLOUT NAILS

Fig. 59.—FELT AND TILE BATTENS COMPLETE, READY FOR THE TILES TO BE FIXED

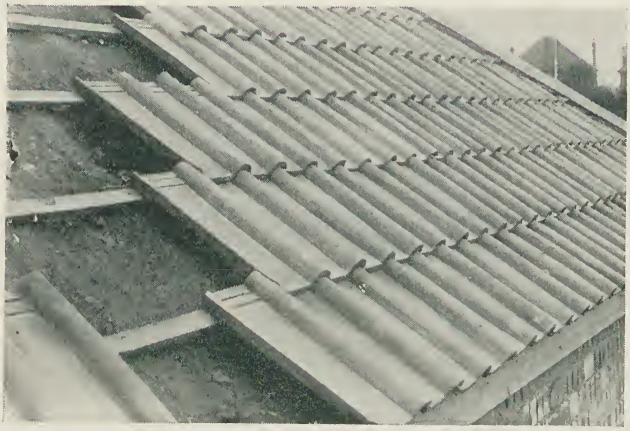


Fig. 60.—BOND AND LAP OF BRIDGWATER TILES

Fig. 61.—THE EAVES READY FOR THE GUTTER

Fig. 62.—THE HIP TILES WELL BEDDED AND POINTED

These can be seen at the top right of the photograph.

Fig. 63.—THE ART OF THE PLUMBER
A jointless lead collar round the soilpipe ventilator.

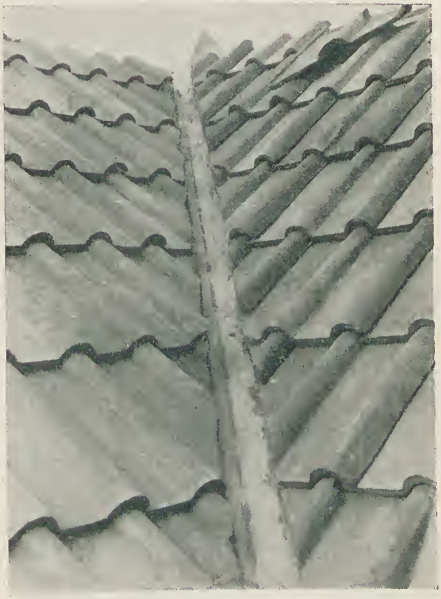


Fig. 64.—TILING CUT TO LEAD VALLEY

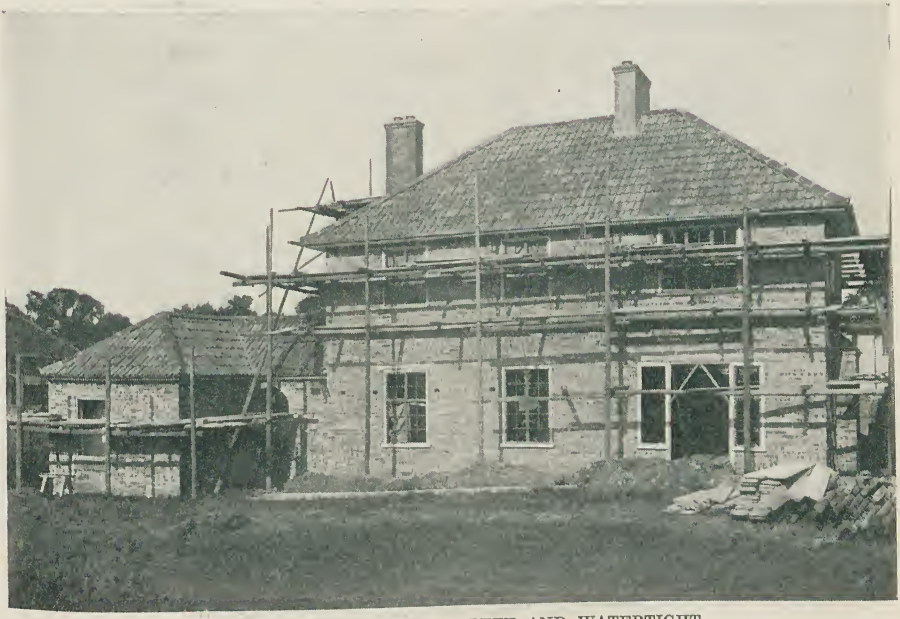


Fig. 65.—THE ROOFS COMPLETE AND WATERTIGHT

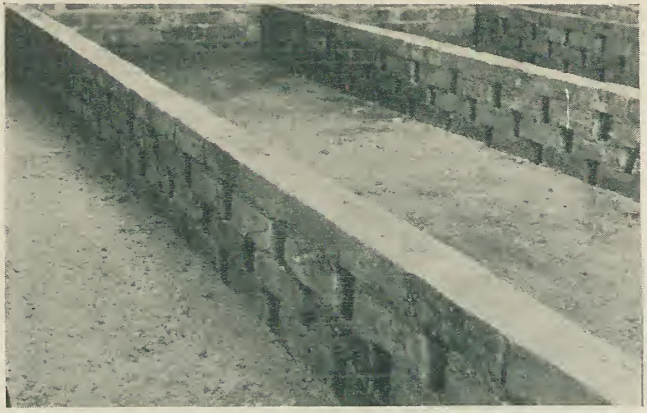


Fig. 66.—SLEEPER WALLS ON CONCRETE SURFACE

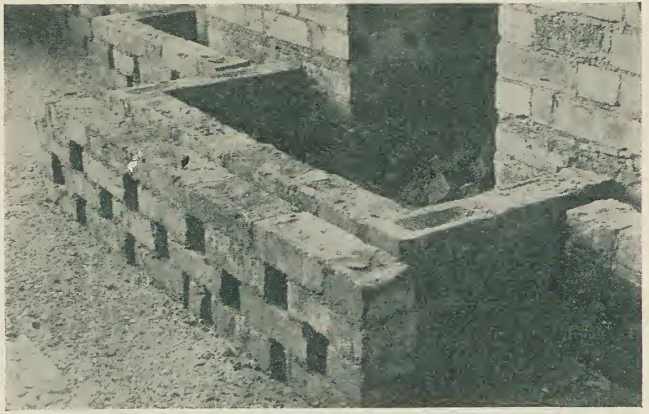


Fig. 67.—FENDER WALL FOR LIVING-ROOM HEARTH

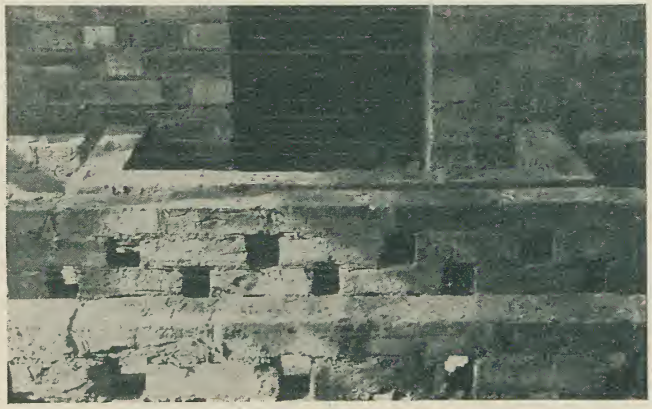


Fig. 68.—HONEYCOMBING OF SLEEPER WALLS

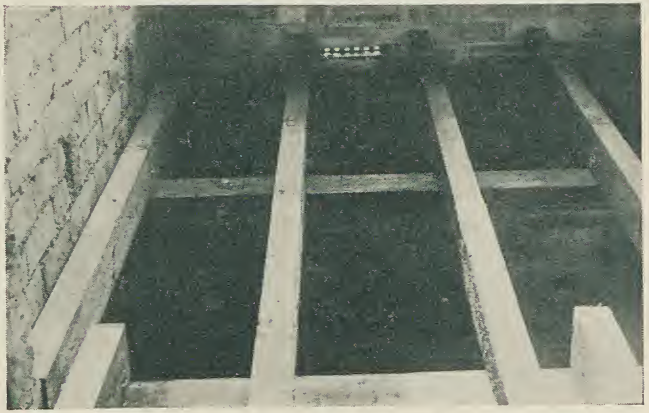


Fig. 69.—THE GROUND-FLOOR JOISTS AND VENTILATING AIR BRICK

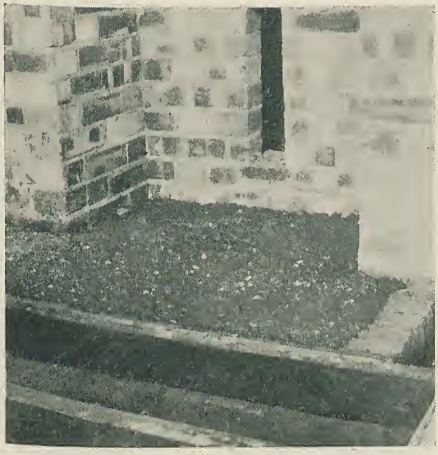


Fig. 70.—THE HEARTH BUILT UP SOLID IN CONCRETE

Fig. 71.—CONCRETE SLAB PARTITION ON FIRST FLOOR

Fig. 72.—THE CEMENT RENDERING COMPLETE AND THE STEEL CASEMENTS FIXED

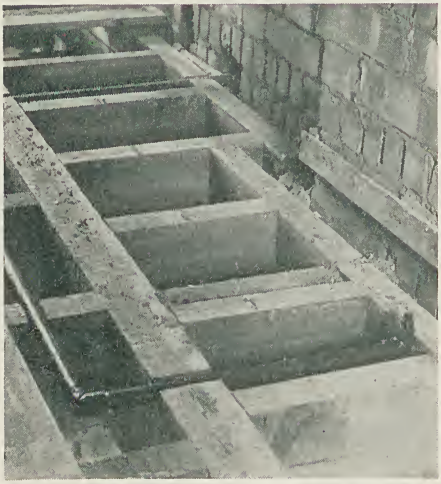


Fig. 73.—THE GAS PIPES IN THE FLOOR

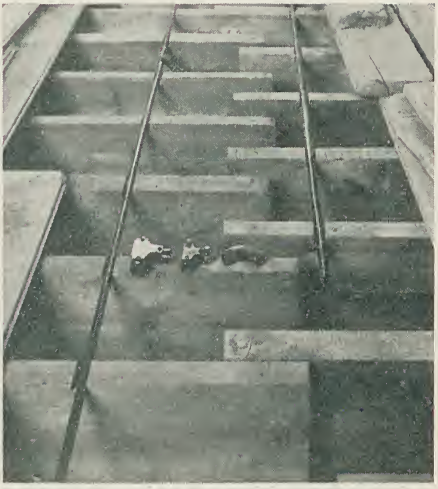


Fig. 74.—THE ELECTRIC CONDUITS

The joists are notched to form a recess for the lengths of conduit or gas tubing which are placed in position and secured by couplings as the work proceeds. The notches are started by the handsaw and the waste afterwards removed by means of a wood chisel. In the right-hand picture can be seen inspection Tees and elbow used for making T junctions and right-angled turns in the conduit run.

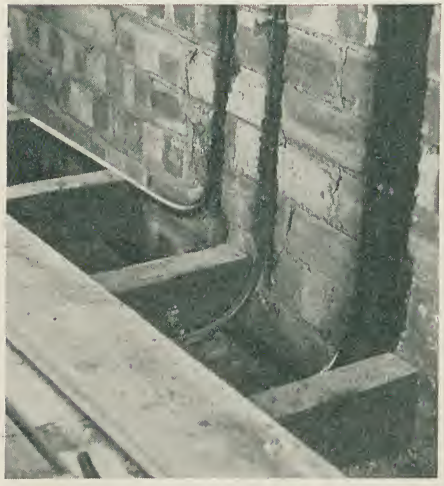


Fig. 75.—THE CONDUITS IN THE WALL

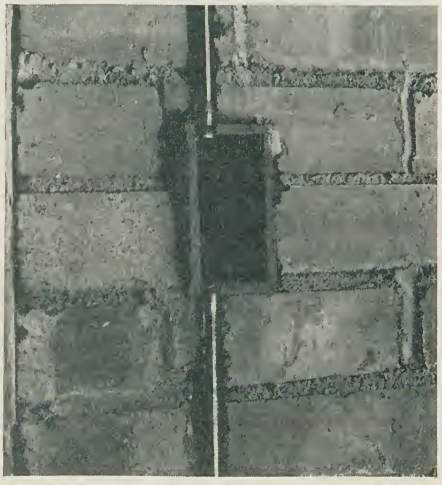


Fig. 76.—A SUNK SWITCH BOX

In concealed work it is often necessary to run a length of conduit tubing from a wall. This is usually the practice in high-class work whenever the house is wired during construction.

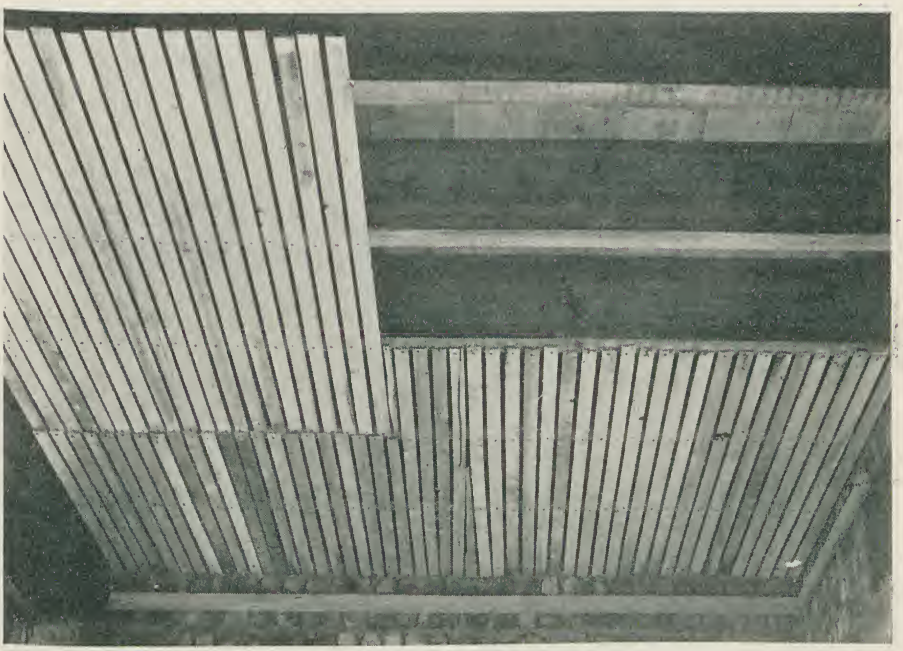


Fig. 77.—LATHING THE CEILINGS

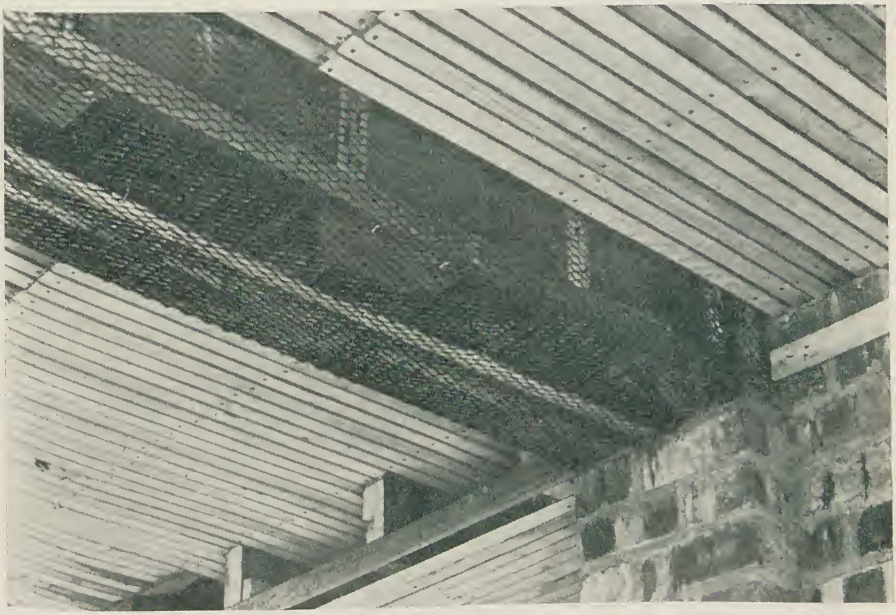


Fig. 78.—EXPANDED METAL LATHING OVER BEAMS TO FORM A KEY FOR THE PLASTER

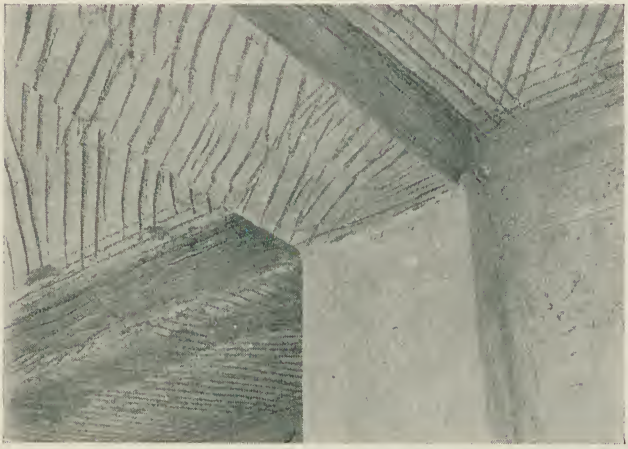


Fig. 79.—THE RENDERING COAT OF PLASTER

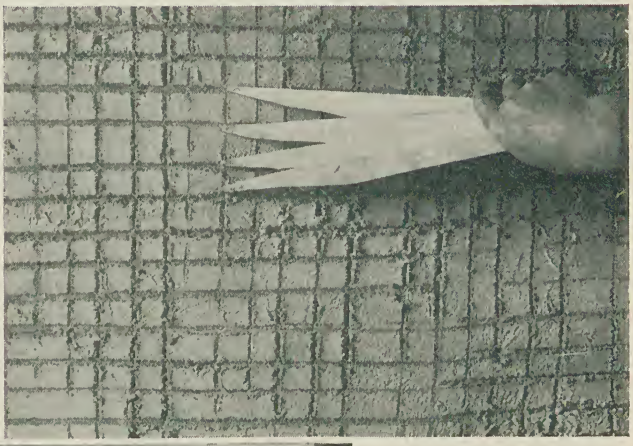


Fig. 80.—THE PLASTERER'S "SCRATCH"

Fig. 81.—PLASTERER USING WOODEN FLOAT

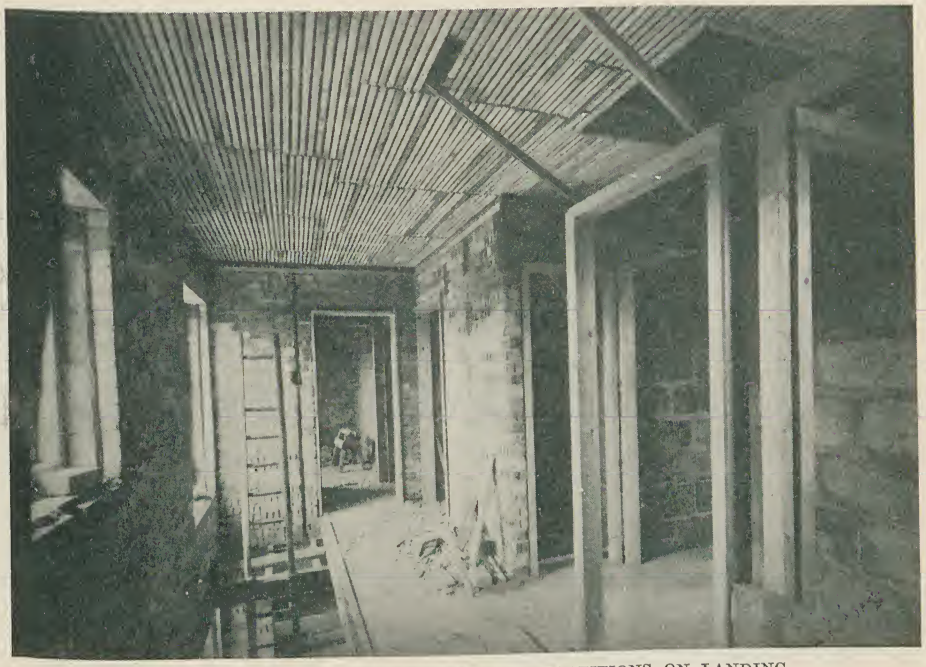


Fig. 82.—SETTING DOOR FRAMES AND PARTITIONS ON LANDING

Fig. 83.—THE HALL, SHOWING LANDING FLOOR AND STAIR TRIMMING

Fig. 84.—STAGES IN FINISHING WINDOW JAMBS AND CILLS

Fig. 85.—JAMB RENDERED IN CEMENT

Fig. 86.—RED TILES BEDDED ON CILL

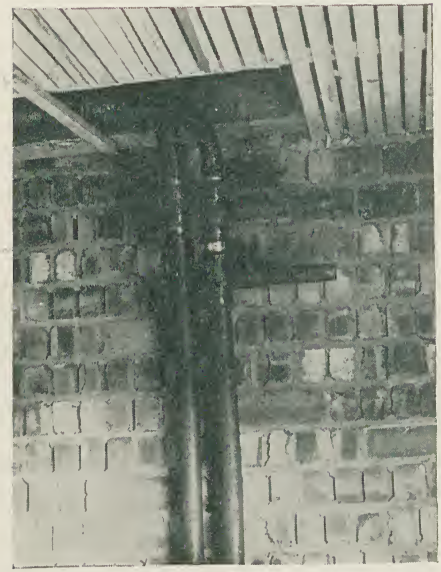


Fig. 87.—FLOW AND RETURN PIPES BETWEEN BOILER AND HOT-WATER CISTERN

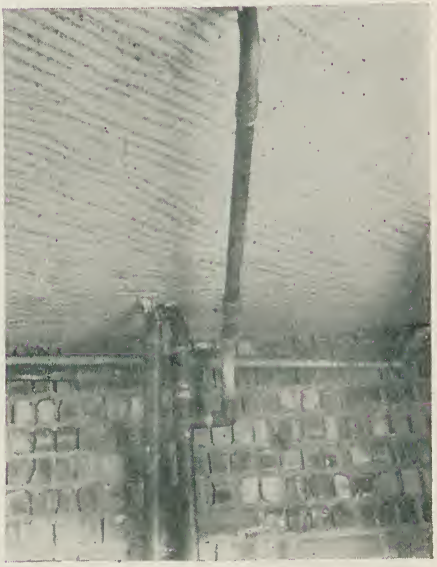


Fig. 88.—FLOW AND RETURN PIPES AND BRANCH TO TOWEL RAIL IN BATH-ROOM OVER

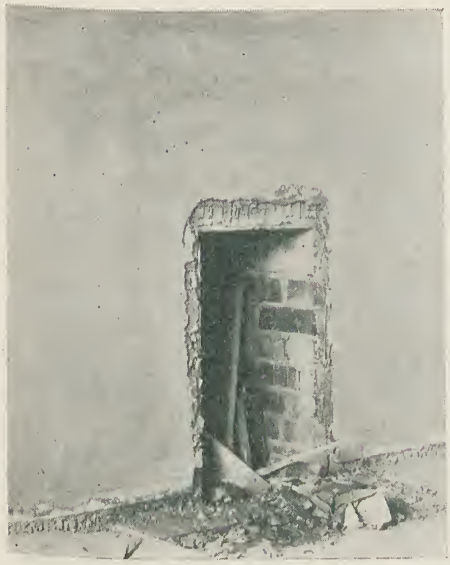


Fig. 89.—FIREPLACE OPENING READY FOR INTERIOR AND MANTEL

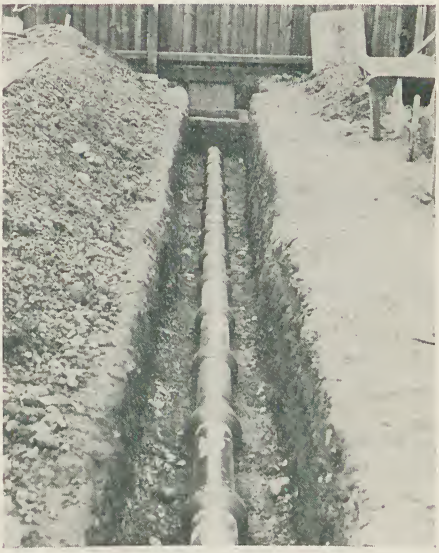


Fig. 90.—MAIN DRAIN—HOUSE TO SEWER

Fig. 91.—HOUSE DRAINS TO FIRST MANHOLE

Fig. 92.—INTERNAL DOOR JUST HUNG

Fig. 93.—THE UNDER SIDE OF THE STAIRS —JUST FIXED

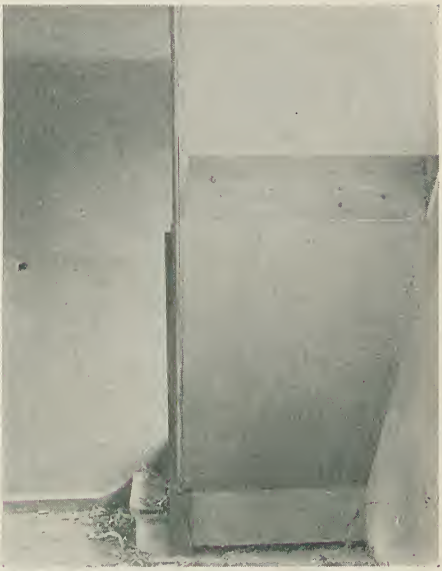


Fig. 94.—THE UNDER SIDE OF THE STAIRS —PLASTERED

Fig. 95.—ONE OF THE LIVING-ROOMS COMPLETED

BUILDING TIMBERS

PRACTICAL NOTES ON SOFTWOODS

ALL building timbers may be divided into two classes—hardwoods and softwoods; a classification which represents the division between coniferous and deciduous trees. One of the greatest difficulties in the way of wood users is to obtain a standard name for a given wood. Thus Douglas fir, one of the commonest building woods exported from Canada, is known commercially as British Columbia fir, red fir, yellow fir, Douglas spruce, Oregon pine, and Oregon spruce, to name only one example. And even the term English oak has been held to describe not the oak grown in England, but a species of wood common throughout northern Europe. An attempt is now being made all round to produce a standard classification, but in this article, while the standard name will be employed in all cases where it is in common use, the other trade names will, where they have been used in the past, be given also.

Definitions

It is useful to define some of the terms used in connection with building timbers, both in specifications and by the timber merchants. The following are most likely to be met with :—

Grain

The term coarse grain is applied to woods of rapid growth, with wide annual rings showing in cross-section. Fine grain, on the other hand, denotes a wood of slow growth. In selecting a wood for strength, a fine-grain wood is most likely to be the stronger.

Annual Rings

These are formed by the annular deposit of wood each year. These rings are divided into two portions, spring wood and summer wood. Spring wood is lighter in colour, and the age of the tree is clearly shown by the number of rings of dark summer wood in the trunk.

Heartwood

This is the inner part of the tree, and is stronger, denser, and more durable than the outer part.

Fig. 1.—STENCILLING THE SHIPPER'S MARKS ON THE ENDS OF GRADED PLANKS

Sapwood

The live portion adjoining the bark. It is lighter in colour than heartwood and is less durable.

Air Dry

This indicates the moisture condition which the wood eventually assumes when exposed under cover to the natural climatic drying conditions. This varies according to the time of year and size of the timber, and a standard condition of 12 per cent. is generally assumed, although it is often found in practice that an air-dry piece of wood contains a much greater percentage in a damp season.

Seasoning

This is the process of removing moisture from wood, and may be done by air drying or kiln drying. If a piece of wood is said to be oven dry, it indicates that it has been subjected to a temperature of 100° C., and that for practical purposes all the moisture has been expelled.

Green Timber

Wood growing, or recently cut up, is so called before the drying process has begun.

Fibre Saturation

In seasoning, this represents a condition of the timber after the free moisture has been evaporated but while the cell walls are still saturated.

Most species contain about 30 per cent. of water at this point, and the wood has the same volume as when green. After this point the volume decreases with further evaporation, and the strength increases. It should be remembered that while green timber is weaker than seasoned, failure, when it does occur, is less sudden.

Softwoods

These are the chief building woods imported. The principal European countries which export softwood to the United Kingdom are Finland, Russia, and Sweden. Smaller quantities are also imported from Norway, Latvia, Lithuania, and other Baltic states. The wood for building purposes is almost exclusively the pine (*Pinus sylvestris*), and the species is known as redwood. The pine is shipped in almost all possible sizes, from planks 11 in. by 4 in. to laths $\frac{3}{16}$ in. by 1 in. It is also referred to commercially as "Swedish" red or yellow wood, "Finnish" red or yellow wood, the phrase denoting the colour of the wood in distinction from the spruce, or white wood. This last-named is usually referred to in the timber trade as "white wood," and is imported from the same countries that export the pine.

Russian Pine

This wood, from Archangel, is still one of the best and most widely used of the softwoods for all constructional purposes. The annual rings are close, as the trees are of slow growth, and now that the import is controlled the quality is strictly checked. On account of the ease of transport, it must always remain the cheapest when prices are not artificially controlled. Wood shipped from Leningrad has not the special excellence of the best Archangel boards, and is similar to Finnish.

Finland

The trees vary according to their district, those in the north and east parts of the country being close-grained, but the boards are not so large as from Archangel. In other parts of Finland, where the trees grow more quickly, the wood is softer and more sappy, with fewer rings to the inch in section.

Sweden

The wood is similar in quality to that from north and east Finland, but has a more pinkish shade of colour. While north Swedish timber is reasonably free from knots, that in the south, grown more in the open, is often unduly knotty. Sweden is also an exporter of white wood, and that shipped from Söderhamn is considered some of the best in Europe.

Baltic Ports

Wood from these states is more resinous than the foregoing, and not equal to the best shipments from Russia and Sweden, although quite suitable for less expensive work.

Canadian Softwoods

Eastern White Pine	Eastern Hemlock
Western Yellow Pine	Western Hemlock
Western White Pine	White Spruce
Red Pine	Black Spruce
Douglas Fir	Red Spruce
Western Red Cedar	Sitka Spruce

These names are now commonly used in the Canadian export market, and have the advantage of a certain amount of agreement with the botanical classification. It should be noticed that the words "red" and "yellow," when referring to European timbers, are terms referring to the same trees, but that Canadian red and yellow pine are entirely different woods. The pines are all of the *Pinus* family, the spruces of the *Picea*, the hemlocks of the *Tsuga*. Douglas fir is in a class by itself, being neither a true fir (*Abies*) nor a true hemlock, but, as the Latin name states, *Pseudo Tsuga*.

Douglas Fir

This is becoming by far the most important building wood exported, but transport is a consideration, as the best forests are on the Pacific seaboard. The tree grows to a great height, with a branchless trunk which often reaches 100 ft., and therefore converts into scantlings very free from knots.

The flag-pole in Kew Gardens, 214 ft. high, is a single spar of Douglas fir, and the durability of the wood is exemplified by the mast at the Crystal Palace, which until quite recently was in use although erected in 1865.

The sapwood is shallow, being between $1\frac{1}{2}$ in. and 2 in. in depth, and easily distinguished by its light shade from the heartwood, which ranges from yellow to reddish brown. This heartwood is very hard when seasoned, and although the wood possesses about the same mechanical strength as pitch pine from the United States, it is considerably lighter, weighing 37 lb. per cubic foot.

Douglas fir is used for heavy structural work, floors, and general carpentry ; also, when planed, it is a good material for doors and windows. All timbers should be marked "Atexo Canada" or "Cantum Canada."

White Pine

This wood is also known as Weymouth pine, Ottawa pine, Quebec pine, and yellow pine—this last name not to be confused with western yellow pine, which is another variety.

Its strength is less than that of some of the harder pines, and it is therefore unsuitable for heavy structural work, but for ordinary building joinery it is very serviceable although expensive. There is little difference between the colours of the heart and sapwoods, the latter being of a

Fig. 2.—TIMBER WAITING FOR CONVERSION AT THE MILLS
The logs are drawn out of the water up the escalators on the right into the sawing hall.

slightly darker straw colour. White pine is excellent for interior joinery, as it works very easily, but the ease with which this wood cuts in any direction has made it especially sought after by pattern makers.

Western White Pine

This is a similar wood to white pine, but, as the name implies, grown in the western provinces. It is slightly less durable when used as a constructional timber, but may be employed for internal joinery, as it takes both paint and enamel well.

Western Yellow Pine

This wood is also known as British Columbia soft pine, California white pine, and Ponderosa pine, and grows in forests mixed with Douglas fir.

The wood has a thick, yellowish-white sapwood, an orange-brown heartwood, and works easily and smoothly without splitting or splintering. Yellow pine is liable to the disease known as blue stain, which is due to a fungus present in the timber. The wood contains a large proportion of resin, which may be found completely surrounding some of the knots. It takes paint and enamel well, and can be used for outside weather-boarding and general joinery, but quickly decays in contact with the ground unless treated with creosote or other preservative. For domestic work it is a suitable wood for rafters and joists, in which form it is usually imported, but should not be employed for heavy constructional work.

Red Pine

In some markets this wood has assumed the misleading title of "Norway pine," which is most unfortunate, as the wood is not a native of any country outside Canada and the United States. The colour of the sapwood is almost white, and the heartwood a light red; the tree contains more resin than white pine, which makes it less easy to work.

The wood is soft, and with a straight grain, it is therefore most used for spars and masts, but, like western yellow pine, is liable to decay when in contact with the ground. As, however, the wood is readily treated with preservatives, it is useful for piling and dock work after treatment.

Eastern Hemlock

This wood is also known in England as hemlock spruce, but it is not much exported, and for building work, although fairly stiff, splinters easily. It is mentioned here to avoid confusing it with western hemlock, a much superior wood, whose virtues have been somewhat overshadowed by this eastern relative.

Western Hemlock

Also known as British Columbia hemlock, grey fir, and Alaska pine, the last two names being introduced in the hope of dissociating it from the eastern variety. Western hemlock is a fine-grained wood, sometimes of a pinkish-red colour, the sapwood, which is from 1 in. to 3 in. thick, being nearly the same shade as the heartwood.

The wood takes paint well, as it is practically free from resin, and can be brought to a good polished surface. In situations either continually wet or dry it remains sound, but will decay where dampness occurs unless treated, and cannot be considered more durable than the spruces. Although not as hard as Douglas fir it is nearly as strong, as well as being one of the heaviest of Canadian softwoods, weighing about 30 lb. per cubic foot. Seasoning is slow, owing to the high moisture content, and care should be taken before using this wood to see that it is properly seasoned either by air or kiln drying. As western hemlock is durable under entirely wet or dry conditions, it can be used for submerged piling and dock work, as well as for interior joinery.

Canadian Spruces

These three spruces are not much used in building except for form work in connection with reinforced concrete, and, on account of their resilience, scaffold planks. The Sitka variety is a very useful wood, being the foremost wood in the world for the construction of aircraft, on account of its light weight combined with strength; it does not splinter readily, and can withstand sudden impact.

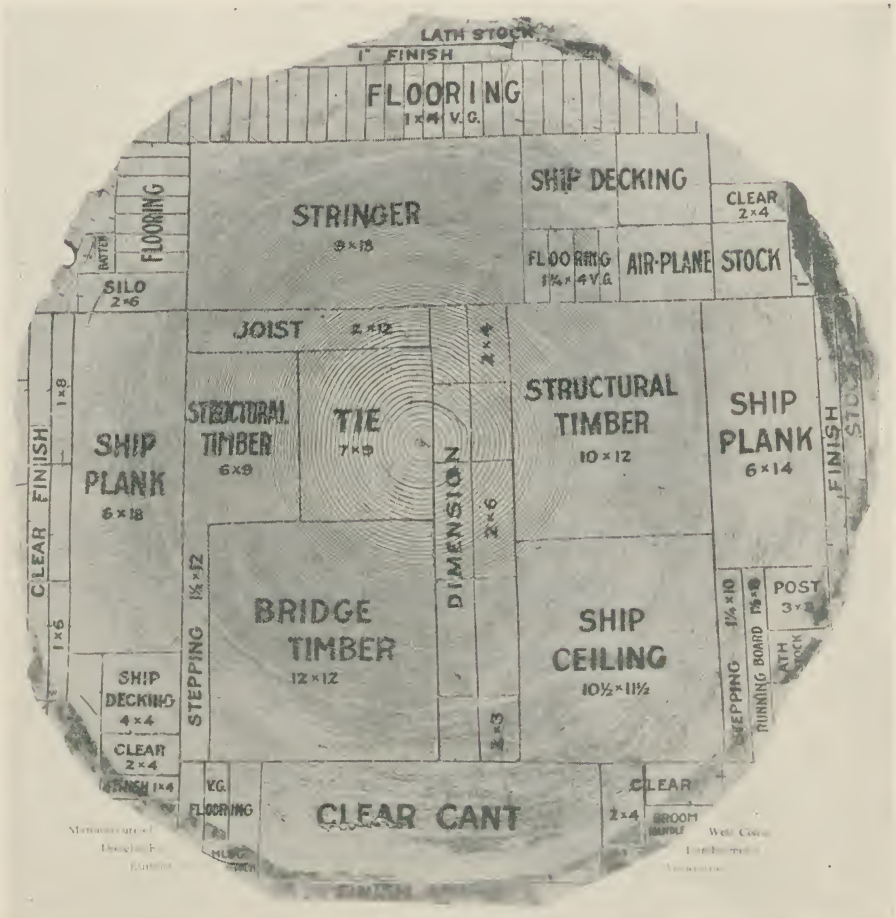


Fig. 3.—END MARKING ON DOUGLAS FIR, SHOWING METHODS OF CONVERSION OF A LOG

Cedar

The two native cedars of Canada are known as eastern and western, and as they do not overlap anywhere in the Dominion the names describe them sufficiently to prevent confusion.

Eastern cedar is a very light wood, weak, brittle, and straight-grained, but remarkably durable, insect-resisting, easy to split, and the most decay-resisting Canadian wood. For these reasons it is extensively used for shingles and laths. Western cedar has all these defects and virtues, and forms about 87 per cent. of the total cedar cut in Canada each year. Although the majority of the wood is converted into roofing shingles, a certain amount is employed in house construction and joinery. It is one

of the few woods practically immune from the attack of dry rot, and having a slight aromatic odour which moths dislike is useful for the construction of clothes cupboards and chests.

Specification—Canadian

It has been suggested for some time that a definitely worded specification, assigning timbers having certain defects to certain classes, should be standardised amongst all timber users. It is a well-known fact that for certain timbers sapwood is not considered a defect, as it does not affect the strength of the wood. It may be less durable and therefore, in small sizes, harmful, especially for exterior work. But the old specification ruling out sapwood and knots is something of an anachronism to-day. In 1911 the American West Coast Lumber Manufacturers' Association produced a specification grading softwoods into four grades, known as " Clears," " Selects," " Merchantable," and " Common." The wording of this specification is so good that it is worthy of universal adoption. It runs as follows :—

Clears shall be round lumber well sawed, one side and two edges free from knots and other defects impairing its use for the probable purpose intended. Will allow in dimensions larger than 6 in. by 10 in., pitch pockets when not extending through the piece ; light-coloured sap on corners not exceeding 3 in. on face and edge ; knots 2 in. and less in diameter, according to size of piece, when on one face and one half of each corresponding edge, leaving one face and upper half of each edge clean.

Selects shall be sound strong lumber well sawed. Will allow in sizes over 6 in. knots not to exceed 2 in. in diameter, varying according to the size of the piece ; sap on one corner not to exceed 2 in. on both face and edge ; pitch pockets not to exceed 6 in. in length. Defects in all cases to be considered in connection with the size of the piece and its general quality.

Merchantable shall be strong sound lumber well sawed, free from shakes, large, loose, or rotten knots, and defects that materially impair its strength, well manufactured and suitable for good, substantial, constructional purposes. Will allow slight variations in sawing, round knots, pitch pockets, and sap on corners, one-third the width and one-half the thickness or its equivalent. Defects in all cases to be considered in connection with the size of the piece and its general quality. In timber 10 in. by 10 in. and over, sap shall not be considered a defect. Discoloration through exposure to elements, other than black sap, shall not be deemed a defect excluding the timber from this grade in otherwise conforming to merchantable grades.

Common.—This grade shall consist of lumber having knots, sap, and other defects which exclude it from grading as merchantable, but of a quality suitable for rough kinds of work.

Branding

The marking of timber on the edge with various letters and symbols, usually in colour, is one of the most important matters in connection with the quality of imported woods. The marks which are placed on sawn timbers by the shippers denote certain qualities upon which the importer can depend, and the reliability of these markings is so generally recognised that cargoes are often purchased on the reputation of the brand alone. A Swedish, Finnish, or Russian shipper may export five or six different grades of wood in the form of battens or deals, and each grade will have a symbol stamped on every piece of wood in that grade. Thus, the best quality may bear in red the letters A.F.N., and the second best P.Y.S., and so on. These shipping marks are all scheduled and published, and one has only to refer to the list to see at once what timber has been delivered to the job.

Each country as a rule also brands in distinctive colours ; thus Russian timber is hammer branded, and has in addition the grade mark on the edge or flat in black or red pencil, thus—I, II, III, 4.—indicating first-, second-, third-, and fourth-grade timber ; the best Swedish is stencilled in red, inferior qualities in blue ; Norwegian in blue paint ; Finnish sometimes white, or red. Canadian timber is stencilled in black and white, and United States marked with red chalk on the sides. Another common term is " unsorted," meaning that the load includes all the four best grades of wood as they come from the saw.

Grading

In Europe there is no absolute system of grading, as in Canada and the United States. Each mill adopts more or less its own standard, which usually comprises " unsorted," 5th grade and 6th grade, for timber shipped from the Baltic.

The best northern European White Sea ports adopt a general system, which is roughly :—

1st Grade—free from all defects.

2nd Grade—small round knots and small defects allowed.

3rd Grade—a larger number of knots and small defects.

4th Grade—definitely knotty, having dead hard knots and waney edges.

An accumulation of small faults in one grade in a single piece of timber will relegate it to the grade below.

The first three grades of the above list are included in what is called " unsorted " timber. This slightly varies from Swedish and Finnish grading, but for purposes of comparison it may be said that fourth-grade Russian is equal to fifth-grade Finnish wood.

" *Unsorted* " timber from northern Europe must have a very large percentage of planks with no knots or defects and very little discoloration. It is difficult to get an exact comparison between European and Canadian

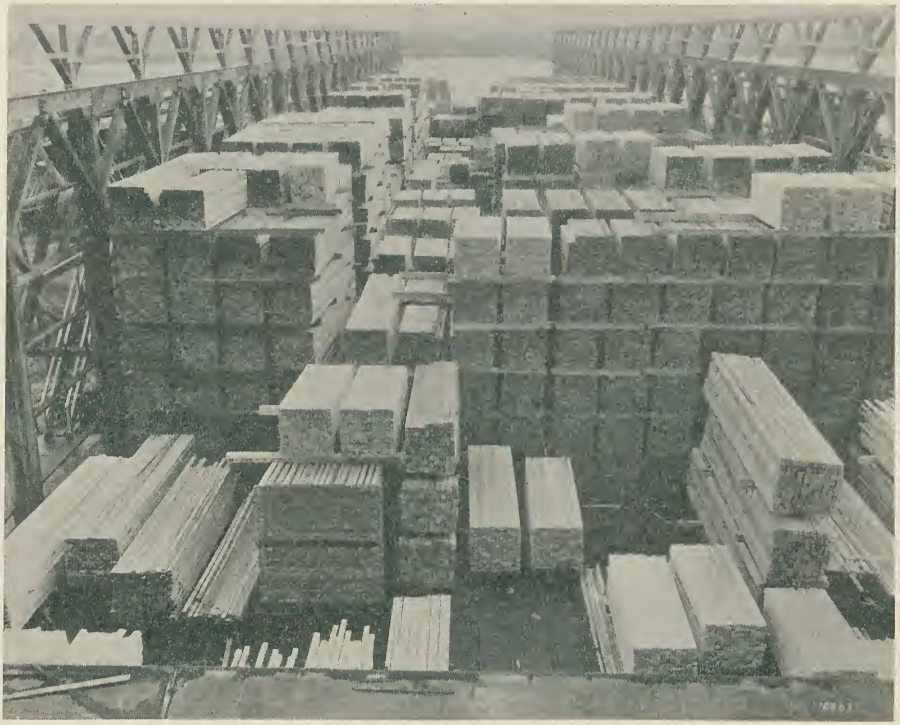


Fig. 4.—SAWN TIMBERS OF VARIOUS GRADES WAITING SHIPMENT IN A CANADIAN TIMBER YARD

grading; it would appear that the Swedish system is stricter as regards discoloration, and allows of no variation of sawing, although one must add that the Canadian imports have improved in this direction.

There is a noticeable difference between the best grades of Swedish and American timber with regard to the knots allowed. Clear timber in America should be entirely free from knots, but both "firsts" and "seconds" from Sweden admit a few so long as they are round.

Spruce is graded in similar manner to the pine, but high-grade wood is scarce, on account of the presence of the many small knots which are common in this wood.

Measure of Timber

Imported softwoods under the Board of Trade classification are calculated in loads of 50 cu. ft. instead of per cubic foot, as is the practice with hardwoods.

In Canada the unit of measurement is the *foot board*, which is the value of a piece of wood 12 in. by 12 in. by 1 in. thick.

In the United Kingdom the unit is the "standard." There have been

many different standards in the past, but the " Petrograd standard " is to-day the basis of measurement for softwoods not only here but in South Africa, France, and over a great part of Europe.

Originally the standard was composed of 120 pieces 12 ft. by 11 in. by 1½ in. thick, and contained 165 cu. ft., or 4·6723 cu. m., or 1,980 ft. board.

The " standard " is used for all kinds of timber except prepared flooring, which is sold by the 100 sq. ft. without reference to thickness ; this measure is called " the square."

Other terms are deal, batten, board, scantling, and plank, each denoting a definite sort of timber. As the Canadian and European measures of these practically agree, the Swedish definition may be taken as near enough.

Deal is a piece of wood 8 in. by 2 in. and upwards.

Batten is a piece of wood 6 in. by 2 in. and upwards.

Board is a piece of wood 1 in. thick and under.

Scantling is a piece of wood 3 in. and under in thickness and 5½ in. and under in width.

Plank is a piece of wood 2 in. by 11 in. and upwards.

Decay of Timber

Wood is subject to two causes of decay—fungus and insect, unless proper steps are taken to preserve it.

Dry Rot

The commonest and most dangerous is the fungus growth known as " dry rot " (*merulius lacrymans*). The name is misleading, since it describes the condition of the timber after the attack, but the fungus cannot exist unless there is dampness to feed its growth.

It is important to recognise dry rot, so that prompt action may be taken, for although difficult to treat it can be cured, and the earlier the diagnosis is made the better. The fungus produces snow-white mycelial mats, from which moisture drops exude, hence the name (*lacrymans*), and when exposed to the light, bright yellow patches appear. From the centres of the growth, cobweb-like strands are sent out which pass over brickwork and plaster, carrying the infection to distant, sound wood. If left undisturbed these strands will feed on the new wood, sometimes becoming as large as small ivy shoots ; thus a whole house may become infected from one damp, ill-ventilated spot.

The rot is brown in colour, and when advanced will powder between the fingers. After a time soft, fleshy fruit bodies develop, which disseminate millions of spores through the air. These fruit bodies may attain large sizes, they are soft and tough, and as they develop become ridged. The red spores live in these ridges, and extreme care should be taken in removing or even touching one of the fruit bodies, as these spores,

which are highly infectious, may lie dormant for years on sound wood, awaiting the exact humidity conditions to spring to active life.

Signs of Dry Rot

The presence of dry rot is detectable by :—

(1) A damp, musty smell when the room is closed.
(2) The warping of skirtings and floorboards.
(3) Surface cracks on the floor joinery.
(4) The appearance of the spores as a fine, rusty-coloured powder.

Wood attacked by dry rot gives out a dead sound when struck, and a sharp gimlet can be pushed in with ease and withdrawn.

Prevention of Dry Rot

The prevention of dry-rot attacks is becoming more difficult, for the fungus spores are so widespread that the only sure way is to take care that the conditions of damp and stagnation are never present under the floors. Well-ventilated wood in dry situations will not develop dry rot, even though the spores are present on the wood. Only one wood in general use is known that is immune from the pest under damp conditions, the western red cedar from Canada. If there is any doubt in laying a floor it is best to treat all the timbers with one of the known preservatives, such as Cuprinol, before framing up.

The Cellar Fungus

This fungus requires much moisture for growth and is often found in damp cellars. It is recognised by its string-like strands, which vary from yellow to nearly black. As the attack develops it covers the wood with a thin yellow skin, and gradually splits up the planks in one direction, thus differing from dry rot, which usually decays the wood into dry cubes. The growth can be stopped by drying out the timber, as the infection is not virulent like dry rot.

Another rarer fungus, somewhat akin to the cellar fungus, has strands of yellow with spots of violet. The timber affected is at first stained a similar yellow, but as the disease continues turns a dark reddish-brown.

The Outdoor Fungi

These are all similar in action, attacking fence posts and all wood buried in the ground or subject to intermittent wetting and dryness. The wood is eaten away until it becomes soft and powdery, and splits. The only protection is to treat all portions of timber below ground level with preservative.

Insect Pests

The other cause of wood decay is the work of insects. These bore into and feed upon the wood until it becomes dead and brittle. The destruc-

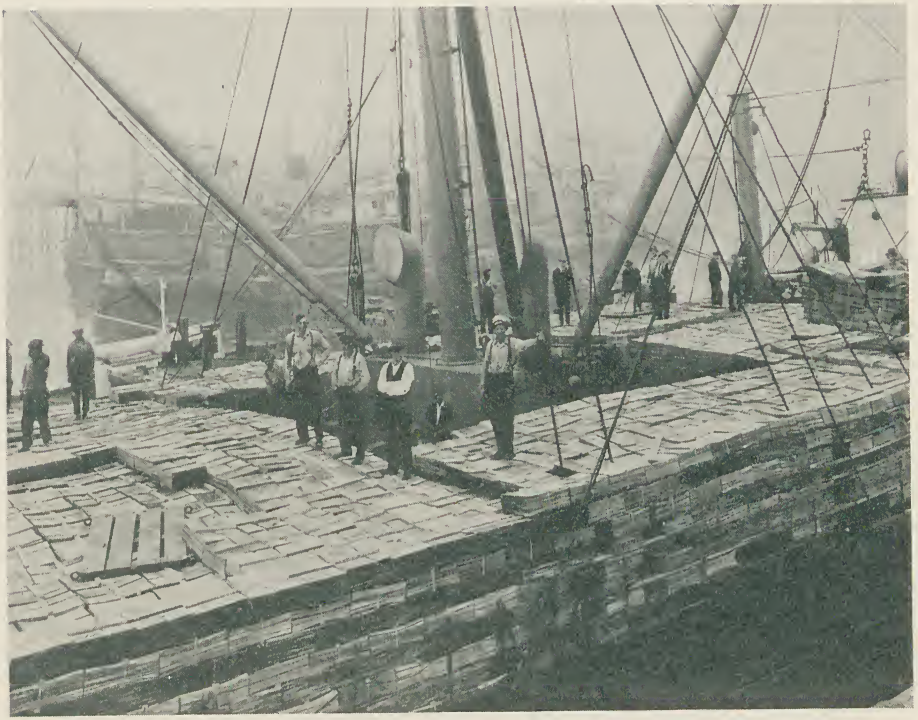


Fig. 5.—CEDAR SHINGLES PACKED READY FOR SHIPMENT IN STANDARD BUNDLES

tion is caused by the larvæ of the beetle boring into the wood and eventually honeycombing it, but it is the grown beetle that bites its way out and forms the holes on the surface which are generally the first indication of trouble.

Death-watch Beetle

The death-watch beetle is now the most famous of these pests, owing to the publicity it has secured through its destructive work in old and historic buildings.

The grown beetles come out of the wood in April, May, and June, laying the eggs in cracks of the wood and old borings. The eggs take from a fortnight to two months to hatch out, and the grubs burrow into the timber, where they live and feed for a period of about two years. The grub then turns into a chrysalis, and later on emerging as a beetle bites its way to the surface, when the process begins all over again.

The death-watch usually attacks large timbers, especially oak, and its presence may be detected by the flight holes, about $\frac{1}{8}$ in. in diameter, through which the beetles escape.

The only cure is to remove all affected parts and apply one of the known

preservatives, such as sulphur dioxide and camphor. The liquid must be allowed to penetrate deeply, by either brushing, spraying, or soaking. The joints and tenons, especially of roof timbers near walls, are the most likely spots for the grubs to lie in ; when old timber has to be cut out and replaced by new the latter should be similarly treated before use with preservative. The warm, dry crevices of roofs in centrally heated buildings seem to be the most favourite haunts of this pest, which works inside the timber until, like a bad tooth, it is entirely decayed under an apparently sound exterior.

Furniture Beetle

This is smaller than the death-watch beetle and usually makes its home in seasoned deal, such as stud partitions and flooring. The life and habits of the furniture beetle resemble those of the death-watch, and the only way is to treat all furniture and wood so affected with a wash.

Lyctus Beetle

This beetle deposits its eggs in hardwood having large pores, and does not attack resinous softwoods with smooth surfaces. It lives only in the sapwood of hardwood trees, usually during the process of seasoning. The wood is reduced to a powdery flour, and when required is often found to be completely destroyed and useless.

Teredo

This worm attacks jetty piling, and any timber under sea water, by boring into the wood until it is honeycombed like a wasp's nest, with holes which may reach even 1 in. in diameter.

Some Mechanical Properties of Softwoods

A rough test for a round balk of timber up to 50 ft. long is to place the ear against one end and listen for the sound of a light blow struck at the other. If the sound is distinct the wood is in good condition, but if the timber is decayed the sound will be faint, or the blow even quite inaudible.

Defects

Heart shakes are radial splits which extend from the centre of the log outwards, and where several of these occur it is termed a " star shake."

Seasoning shakes are radial splits which extend from the circumference towards the centre.

Ring shakes, sometimes called cup shakes, are openings between the annual rings which may extend right round the log.

The Forest Products Research Laboratories of England and Canada have recently compiled data from tests carried out on various timbers. The attempt to produce results comparable to those employed in designing iron and steel structures is complicated by the fact that, while differ-

ent pieces of these metals give approximately the same results under test if they are of the same quality, pieces of timber that appear to be similar to one another do not do so. This is probably due to variations in climate and rate of growth ; as a general rule slow-growing trees are stronger, as the annual rings are closer together, and in choosing timbers for weight-carrying, the number of rings to the inch showing in the end grain is a good, rough guide to the suitability of the wood.

The tests made by the Forest Products Research in England were carried out on 337 different joists from Gefle and Archangel in an attempt to obtain a mean result, and the data of this, and their tests on Empire woods, are published by H.M. Stationery Office as a small pamphlet. It gives both the maximum bending moment and modulus of elasticity of a number of different scantlings in tabulated form, from 4 in. by 2 in. up to 9 in. by 3 in., in each of the five different grades usually employed in building work.

Safe Loads

In calculating the working stresses it is usual to take a factor of safety of 8 for a safe distributed load on a beam. This figure is high for actual strength, which would probably be safely represented by 5, but in all beams and joists deflection must be avoided. A floor which springs under the tread may be structurally safe, but is unsatisfactory from every other point of view. In choosing beams it should be remembered that while the *strongest* beam that can be cut from a log has its depth to its breadth in the proportion of 10 to 7, the *stiffest* beam has its depth to breadth in the proportion of 7 to 4.

A TABLE OF THE MECHANICAL PROPERTIES OF SOME CANADIAN SOFTWOODS

COMPILED FROM THE RESULTS OF TESTS ON SMALL CLEAR SPECIMENS MADE BY THE FOREST PRODUCTS LABORATORY OF CANADA

Name of Tree	*Weight per Cubic Foot in lb.*	*Maximum Bending Strength in lb. per sq. in.*	*Crushing Strength in lb. per sq. in. Parallel to Grain*
Douglas Fir (Coast.)	37	14,800	5,070
White Pine	27	8,500	6,050
Western White Pine	26	9,200	5,360
Western Yellow Pine	32	10,200	5,550
Red Pine	28	10,100	5,710
Eastern Hemlock	29	9,400	5,150
Western Hemlock	30	11,100	5,680
Sitka Spruce	27	10,400	5,300
Western Cedar	22	7,800	5,070

Specimens were air dry to 12 per cent. moisture content. For bending tests, 2 in. by 2 in. by 28 in. between supports. For crushing, 2 in. by 2 in. by 8 in. vertical to load.

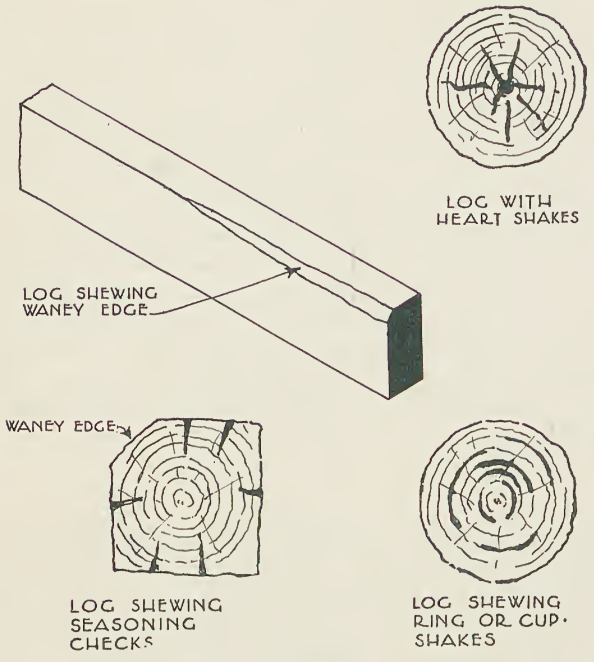


Fig. 6.—SOME DEFECTS IN WOOD

The most important discovery from these tests up to the present has been the close relationship between moisture content and strength.

Moisture Content

It has now been fixed that the moisture content of timber should not be higher than 15 per cent., although timber with as high a content as 25 per cent. has been used for general carpentry work, on the assumption that timber will season further after being placed in position.

The Forest Research Laboratory recommends a moisture content for joinery as follows:—

General joinery work, 15 per cent.

Best joinery of all kinds, 9 per cent. to 12 per cent. for rooms with central heating.

Best joinery of all kinds, 10 per cent. to 14 per cent. for rooms not centrally heated.

Storing Timber

Timber of proper moisture content for good work is often ruined after delivery to the site by being left in the open without cover, especially in winter. The practice of piling joinery in triangular heaps, so that air can get to it, is harmful under rainy or damp conditions, and it would be better preserved by being packed in a close heap. It is equally bad to lay the wood inside the new building before it has dried out and the heating system is running to speed up the drying process.

Painting Timber

Painting timber that has too high a moisture content will do more harm than good. The paint will probably blister, and in any case it will help to retain the moisture in the wood and thus increase the risk of attack by fungus.

HOW TO FIX RUBBER FLOORING AND RUBBER STAIR TREADS

THE increased demand for rubber flooring in recent years is due to its unique features compared with other floor coverings, which may be summarised as follows :—

(1) Good appearance due to development in attractive colourings.
(2) Exceptional wearing properties.
(3) Non-slipping.
(4) Hygienic.
(5) Sound-absorbing.
(6) Abrasion-resisting.
(7) Not easily marked or indented.
(8) Can be made to any design or colour.

How to Prepare Floors for Laying

Numerous are the types with which the floor-layer has to contend, including concrete, asphalte, brick tiled, granite faced, many patented hard-surfaced materials, and wood.

A Special Case

In some cases it is necessary to cover a badly surfaced or very wet concrete, tiled, or other similar floor with wood, to permit the laying of rubber flooring. It is advisable in such instances to keep the wood away from the under floor by building it on shallow battens, thus permitting adequate ventilation.

Tongued and grooved boarding is invariably used, and reasonably smooth and good-class wood, free from excessive knots, etc., should be selected, as this will simplify the preparation of the floor for finally covering.

Preparing the Wood Floor

The best type of floor for rubber covering is undoubtedly the wooden one, and the only preparations necessary for making a successful job are :—

(1) Withdrawing or knocking down all nails, etc.
(2) Levelling.
(3) Filling up all holes, grooves, and knot holes.
(4) Removing all waxy polishes, dirt, grease, etc.

Dealing with Warped Wood Floor

A floor which was originally laid with too new wood will sometimes assume an uneven surface, due entirely to the wood warping, perhaps on account of heat in the room. It will be necessary to plane or sandpaper the parts which have risen, bringing them down to the level of the remainder.

Smoothing Uneven Floor by Machine

Machines are now in common use for " sanding " an uneven floor. These machines are of various types, but the essentials in each case are the same, i.e. an electrically driven revolving high-speed sandpaper-covered roller, and they can be used with great success in levelling any type of floor. A wooden floor is very quickly smoothed with one of these machines, and it cuts out the necessity for planing.

After removing the nails or knocking them in, out of harm's way, the bumps, etc., are either planed or " sanded " and the floor made as level as possible, as the slightest bump will show through the rubber after laying, if not previously removed.

Filling Holes and Cracks

The same remarks apply to holes caused through knots coming out, etc., and these holes must be filled up and then levelled off before the rubber is laid.

A Useful Filling to Make Up

A good filling for these holes is a mixture of sawdust and glue, or sawdust and a very quick-drying varnish. Another filling is sold under the name of " Plastic Wood," which is simply a mixture of sawdust and cellulose in solution. Any of these fillings will prove satisfactory. Spaces between boards which have shrunk must be filled in with thin strips of wood, and then levelled off.

Removing Dirt, Grease, and Polish, and/or Paint and Varnish

The last important point in preparing the floor is to remove dirt, grease, waxy polishes, etc. The dirt may be brushed and then washed off with soap and water containing a little common soda. Grease and waxy polishes which are frequently found on old floors are best removed by first of all scraping with a metal scraper, and finally washing off with a solvent such as naphtha, petrol, turpentine, etc. The solvent should be allowed to dry thoroughly. This is important, because naphtha and petrol are solvent for solution, and turpentine has a deleterious effect on rubber.

It is important that no grease or wax be left in the wood, otherwise great difficulty will be experienced in getting good adhesion of the rubber to the floor.

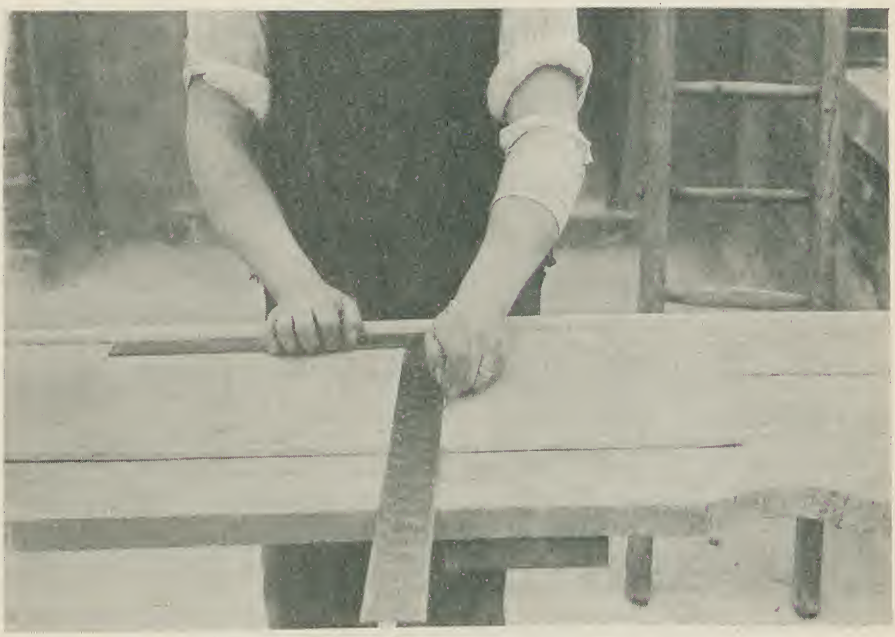


Fig. 1.—MARKING STRIP RUBBER PRIOR TO CUTTING TO SQUARES

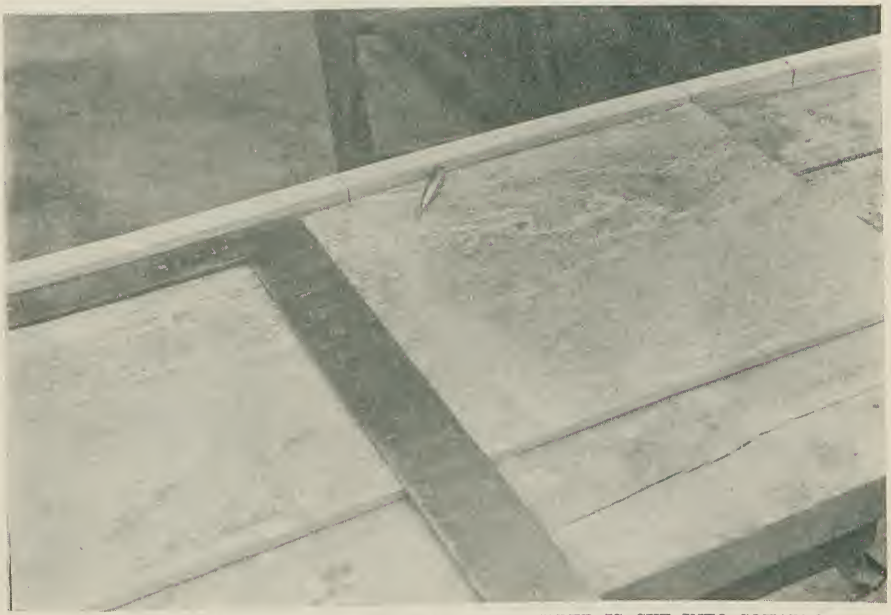


Fig. 2.—THE BENCH ON WHICH THE STRIP RUBBER IS CUT INTO SQUARES
Note the pencil marks on the ledge, indicating lengths to be cut.

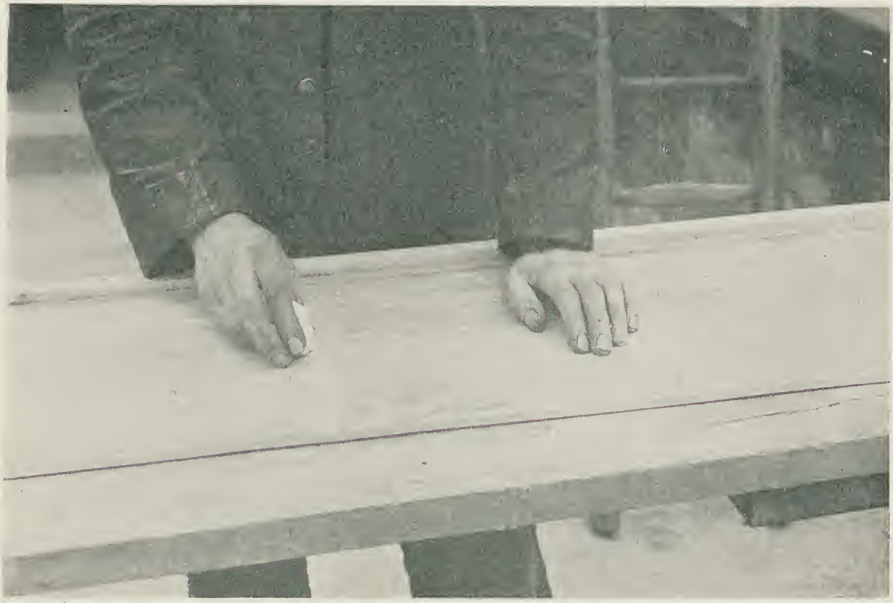


Fig. 3.—WHEN THE LINE HAS BEEN MARKED, CHALK IS RUBBED INTO IT TO MAKE IT CLEAR FOR CUTTING PURPOSES

Fig. 4.—THE SURFACE OF THE RUBBER IS NEXT CUT THROUGH LIGHTLY WITH A CURVED KNIFE

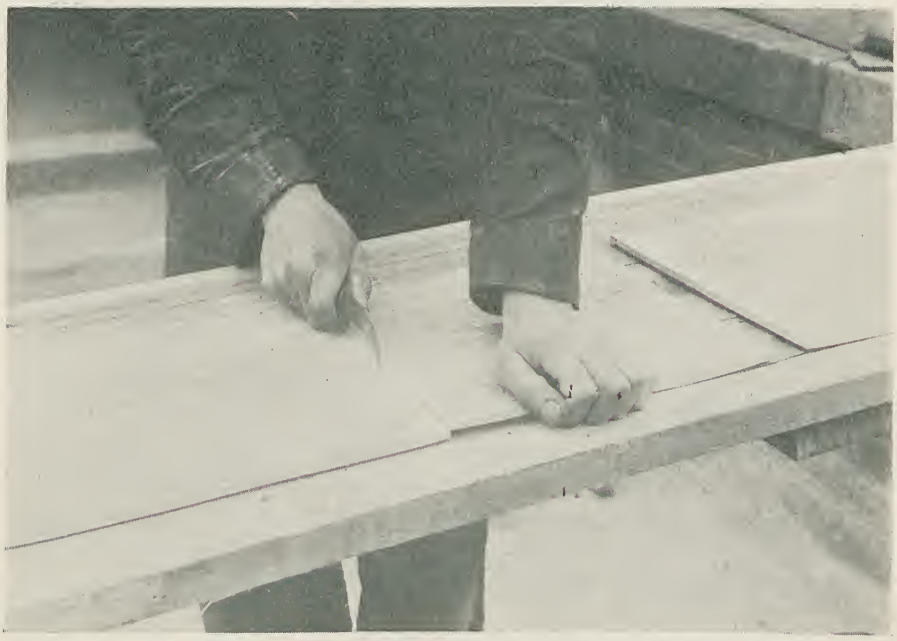


Fig. 5.—CUTTING THE FULL THICKNESS OF THE RUBBER

How to Measure up a Floor for Covering

The main points to remember, when measuring up a room for covering, are :—

(1) Be sure your measuring instruments are accurate.

(2) Take measurements from a fixed point in the room, one which can always be determined at any time.

(3) Make templates from paper or cardboard for any uncertain shapes, such as around doors, counters, pillars, etc.

(4) Take diagonal measurements as a check.

You cannot take too many measurements, but never take too few.

Applying Rubber Solution

The most popular type is the rubber solution. The usual way to apply this is to give the back of the rubber flooring or tiles one thin coat with a brush, at the same time solutioning the edges to render the joints waterproof when laid.

The floor itself is then solutioned by means of a brush or spreader.

If a spreader is used, this can easily be made from a piece of scrap rubber of such quality and thickness as the rubber flooring itself, and cut to a size of approximately 5 in. by $2\frac{1}{2}$ in., just big enough to comfortably hold in the hand.

Only a small portion of the floor is solutioned at a time. When the solvent from the solution has evaporated, which usually takes from 10 minutes to 30 minutes, according to the nature of the solvent, the floor, if necessary, is given a second coat in the same manner, and allowed to dry again for the same length of time. When all the solvent has evaporated from both the solutioned rubber and the floor, the rubber is applied to the floor by starting at one edge and gradually fixing down. A small hand-roller may be run over it subsequently to ensure better adhesion, and dispel any trapped air between the rubber and floor. The process is continued until the floor is covered.

RUBBER COVERINGS

Rubber of a quality similar to that used for covering floors is used nowadays extensively for covering table tops, counters, and even walls.

For Table Tops and Counters

In covering table tops and counters, the wood must be levelled and smoothed as in the case of floors, by planing or sandpapering. A rubber solution is invariably used as an adhesive in such cases, and applied as described above.

The tops of tables must be finished off with a beading round the edges, which may be screwed or nailed on over the rubber and through to the wood underneath.

The thickness of rubber for such jobs is seldom more than $\frac{1}{8}$ in., as thicker material is unnecessary.

Covering Walls with Rubber Sheet

The covering of walls with rubber sheet about $\frac{3}{32}$ in. thick is now becoming more popular, but the walls in such cases should be constructed of materials similar to the many compressed wood or asbestos sheetings now frequently used in house building. Plaster walls are not satisfactory for rubber covering, on account of poor adhesion.

In covering these walls, the rubber and walls are made adhesive by the use of a rubber solution in the same manner as described for floor covering. Sheets of rubber, the same size as the wood or asbestos boards, are applied, and the joints are hidden by 2-in. laths or cover fillets of some description which give a panelled effect, and at the same time help to further secure the rubber and obviate the possibility of its being torn off.

POINTS TO NOTE AND TO AVOID

Like every other kind of floor covering, rubber has its own peculiarities, and there are many little points which must be avoided.

With New Cement or Concrete Floors

In the first place, it is folly to lay rubber direct on *new cement or concrete* floors, or in fact on any damp floor, without first of all putting

Fig. 6.—APPLYING RUBBER SOLUTION TO CONCRETE FLOOR SURFACE WITH A STIFF ROUND BRUSH

Fig. 7.—APPLYING RUBBER SOLUTION TO THE BACK OF THE CUT RUBBER TILING

Fig. 8.—APPLYING RUBBER TILING TO PREPARED CONCRETE SURFACE

Note that two widths of tiling are first fixed to the floor, and the squares are then built out from these in a pyramid shape, in order to keep a constant check on the accuracy of the square angles into which the various units fit.

down a damp-course. Space does not permit us to go into details concerning the nature of these and the several methods of applying a satisfactory damp-course. This will, however, be dealt with in detail in a later article.

It may, however, be assumed that no concrete floor is dry under three months. Rubber is practically impervious to moisture, and does not permit of the dampness escaping. This moisture collects underneath the rubber, and whatever type of adhesive cement or solution has been used in fixing it down, eventually it will be adversely affected, and the whole job in consequence will give trouble from an adhesion point of view. *Dampness in wooden floors* is seldom met with, as there is usually adequate ventilation beneath.

Oil and Grease on Rubber

If rubber is laid in a motor showroom, or any other place where *oil or grease* is likely to come in contact with it in any excess, steps should be taken to remove any accumulation, by means of petrol, soap and hot water, etc. Oil and grease will, in a short time, make the surface of the rubber soft, due to absorption.

When Laying Flooring

When laying rubber flooring, do not use too much solution (if containing a solvent as in rubber solutions) on the back of the rubber itself, as it has a tendency to swell the material and thus delay the laying operations.

Be sure that there is *free circulation of air* in the room in which laying is taking place, if a rubber adhesive is being used, as some of the solvents give off *poisonous fumes, which stupefy the worker.* Also beware of the *inflammability of the solvent* as, in a lot of cases, highly inflammable solvents are used.

Weight

A square yard of $\frac{3}{16}$-in. rubber flooring weighs about 15–16 lb. This is subject to variation according to the quality of the material.

Cutting the Material

The material is usually cut with a hooked knife, similar to that used by those laying linoleum.

We are indebted to the Dunlop Rubber Co. Ltd. for facilities for staging the photographs showing the approved methods of laying rubber flooring.

RUBBER STAIR-TREADS

In making stair-tread rubbers, a shape or former of wood is prepared, upon which the rubber is moulded into shape before vulcanising. Some manufacturers use aluminium shapes, but they are not employed to any great extent.

Stair-tread Rubber Formers

It will be appreciated that seldom are stairs of the same size or shape in two different buildings, hence the necessity for exactly measuring up each individual job.

For Straight Stair

The ordinary straight stair presents little difficulty, as it is only the curve of the nosing which matters, and as it is sometimes the practice nowadays to combine the tread portion with the nosings and risers, a shape on the lines of Fig. 11 is required by the operator to work or mould his rubber upon.

This shape, like all others, is made from fairly low-grade timber, such as red deal. Timber containing large knots or of a very resinous nature should be avoided, as the resin migrates into the rubber during vulcanisation, on account of the heat, and causes discoloration and other defects. There is also the possibility of warping where the wrong kind of timber is used, or if it is not well seasoned.

Fig. 9.—THE METHOD OF USING BACK OF HAMMER TO TAP RUBBER TILING INTO POSITION

Fig. 10.—THE FINAL OPERATION

Surplus rubber solution which has oozed through the joints is removed by rubbing a roll of crêpe rubber vigorously over the joint.

Moulding Rubber to Shape

The rubber is first moulded on to the shape from the raw or unvulcanised sheet, or (in the case of nosings) from a shaped strip which has been forced through a die in a rubber-forcing machine. It is then held to the shape by clamping with a strip of wood or metal, which holds it in position during vulcanisation; in some cases fine cloth is used to secure it.

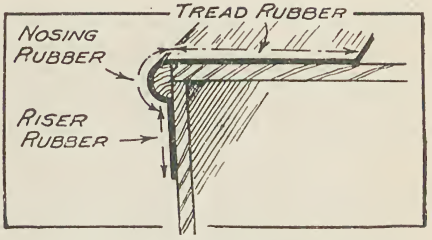


Fig. 11.—SECTIONAL VIEW OF STAIR

Curved Stairs

Where stairs are curved, as they usually are at the bottom of a flight or at the turn at the top, special wooden shapes have to be made to the shape and size of each stair for moulding purposes, but the same principle applies to all, whatever the shape may be. These shapes vary.

There are, of course, many other shapes, but the above represent the average for which one has to cater nowadays.

It will be seen from the sectional view of the shape that, just below the nose portion, the wood is cut away at a slight angle, and not at right angles to coincide with the stair on to which the rubber will eventually be fitted. This is to ensure a slight grip when the rubber is put into position.

Manufacture of Nosings Only

Often it happens that nosings only are required, or nosings with separate treads and risers. In such cases, shapes are made to the size of the actual stair nosings, allowance being made to grip the nosings top and bottom during vulcanisation.

The excess rubber between the grips is cut away after vulcanisation. Here again, it will be seen that the wood at a point where the under portion of the nosing finishes is cut away to ensure a grip of the rubber when fitted to the actual stair.

In cases where nosings are independent of tread and riser, the two latter are usually cut to size from sheet rubber.

Joining Pieces of Wood for Former

Wherever possible, the wooden shapes are made from timber of sufficient width to enable them to be cut out in one piece, as obviously this saves a lot of labour. Should, however, wood of such width not be available, two pieces are joined together by screws, put in at an angle, and the shape made as before.

Rounding the Nosing

In all shapes the rounded portion of the wood which is to form the nosing, is made by using, as far as possible, a hollow or rounded plane familiar to all woodworkers, and finishing off where necessary with a spokeshave.

The correct curve depth, etc., is obtained by employing a gauge, previously cut out of soft metal, to the size of the nose on the actual stair.

It is advisable to keep these gauges, once made, as they often come in useful for subsequent jobs.

The various types of rubber floors, the method of manufacture, and the method of specifying rubber flooring will be found in Volume II.

QUESTIONS AND ANSWERS

How would you prepare a Wooden Floor for covering with Rubber ?

(1) Withdraw or knock down all nails, etc.
(2) Level by either planing or sanding.
(3) Fill up all holes, grooves, and knot holes.
(4) Remove all waxy polishes, dirt, grease, etc.

How may Holes, Grooves, and Knot Holes be filled up in a Wooden Floor ?

By means of a filling such as a mixture of sawdust and glue, or sawdust and very quick-drying varnish, or " Plastic Wood." Spaces between boards which have shrunk should be filled in with thin strips of wood and then levelled off.

What method should be adopted to remove Grease and Waxy Polishes from Wooden Floors ?

First scrape with a metal scraper and then wash off with a solvent such as naphtha, petrol, turpentine, etc. Allow the solvent to dry thoroughly before applying the rubber covering.

What precautions should be taken when applying the Rubber Covering ?

(1) When solutioning the back of the rubber flooring or tiles, use only a thin layer, and apply the brush to the edges to render the joints waterproof when laid.

(2) Solution only a small portion of the floor at a time.

(3) Allow the solvent to evaporate from the solution after application. This usually takes from 10 to 30 minutes.

(4) Take care that no air is trapped between the rubber and floor.

What types of Walls are suitable for covering with Rubber Sheet ?

Walls constructed of materials similar to compressed wood or asbestos sheetings. Plaster walls are not satisfactory for rubber covering, on account of poor adhesion.

How should Walls be covered with Rubber Sheet ?

The sheets of rubber should be the same size as the wood or asbestos boards, and the joints hidden by 2-in. laths or cover fillets of some description, which give a panelled effect, and at the same time help further to secure the rubber and obviate the possibility of its being torn off.

Why should not Rubber be laid direct on new Cement or Concrete Floors ?

Because the rubber is practically impervious to moisture and does not permit of the dampness escaping. This moisture collects underneath the rubber, and whatever type of adhesive cement or solution has been used in fixing it down, eventually it will become adversely affected and will become unstuck.

What should be done with new Cement or Concrete Floors which it is intended to cover with Rubber ?

A damp-course should be laid down on the concrete surface.

Why is Dampness in Wooden Floors seldom met with ?

Because there is usually adequate ventilation beneath.

What happens if too much Solution is used on the back of the Rubber when laying Flooring ?

It has a tendency to swell the material, and thus delay the laying operations.

How are Stair-tread Rubbers prepared ?

A shape or former of wood is prepared upon which the rubber is moulded into shape before vulcanising.

What precaution should be taken with regard to the Wood used for Stair Shapes ?

The shape is made from fairly low-grade timber, such as red deal. Timber containing large knots, or of a very resinous nature, should be avoided, as the resin migrates into the rubber during vulcanisation, on account of the heat, and causes discoloration and other defects. There is also the possibility of warping where the wrong kind of timber is used, or if it is not well seasoned.

How is the Rubber for Stair-treads moulded to shape ?

It is first moulded on to the shape from the raw or unvulcanised sheet, or (in the case of nosings) from a shaped strip which has been forced through a die in a rubber-forcing machine. It is then held to the shape by clamping with a strip of wood or metal which holds it in position during vulcanisation. In some cases, fine cloth is used to secure it.

NOTES ON FIXING IMITATION MARBLE

IMITATION marble, known as synthetic or art decorative marble, has made much progress recently and will probably be used fairly extensively in future as a wall-lining medium.

It is a plaster cement product, and has been found to be most suitable for holding the colours which are in the surface, and not merely on the surface.

The various veins and grainings of marble are imitated. Only one or two firms specialise on the more complicated marble grainings, as the artists for the work have to be specially trained, and it is in their products that the beauties and grandeur of marble are revealed and emphasised. Bright colours, which are unobtainable in real marble, can be produced, and it is in this direction that the near-future decoration of large buildings, offices, luxury flats, and even suburban-type houses will be carried out.

Colours are expensive as they have to be specially made to withstand the effects of efflorescence, caused by dampness. If cheap colours are used the result is disastrous, as the surface becomes patchy in shades.

Sizes of Imitation Marble Panels

The panels generally are made to a thickness of $\frac{3}{8}$ in. in sheets 24 in. by 18 in., and $\frac{1}{2}$ in. thick when made 30 in. by 24 in.

Three Methods of Fixing

There are three methods of fixing to walls, namely, the spot, solid, and dry methods, the latter method being used when it is not convenient to wet the wall. Wood battens are screwed to a plugged wall, the panels being screwed to these in sizes up to 6 ft. by 2 ft. wide, $\frac{3}{4}$ in. thick. The joints are covered with a suitable wood or metal moulding, resulting in an effective panelled scheme suitable for entrance halls, board rooms, and offices, as these can be taken down and replaced with another scheme without damaging the walls.

The Spot Method of Fixing

With the spot method of fixing, which is done for cheapness, the panels are put on the walls with cement at each corner.

It results generally in a badly fixed job, for the panels are liable to

crack by reason of changing temperatures, and wall stresses due to foundations.

As the walls are partly hollow, there is no sound-proofing quality, and panels can easily be damaged where there is no support behind them.

The Solid Fixed Method

Without a doubt the solid fixed method is by far the best, as the panels become an integral part of the wall and result in sound-proofing, especially if the surface has protruding down banding at intervals, and superimposed panels.

Preparing the Wall

A cement screeding of about $\frac{3}{4}$ in. is necessary for a lasting job and the wall should be properly plumbed, a point that is often neglected in these days of quick-time building. The cement screeding should have an admixture of " Pudlo " or some suitable waterproofing element and should be given ample time to dry out.

The work of fixing can begin by putting on the skirting. A solid backing of plaster cement should be used and the thickness should equal the thickness of the panel, which is generally $\frac{3}{8}$ in.

How to Make the Joints Level

As the sheets or panels are fixed, care should be taken to get all joints level, so that no protrusions occur. This is done by punching with the hand. As the fixing cement is solid all over the back of the panel, the panels can be fixed with $\frac{1}{16}$-in. joints between each sheet, which are filled in when finishing off. The sheets generally are bonded, but various schemes result in different courses.

Panelling to Dado Height

If working only to a dado height, the capping, which may be of a contrasting colour, should have a well-finished bullnose with the grain continuing over the curve. Many synthetic marbles have a separate bullnose to their capping, with the result that the veinings do not follow in the right place, and in addition necessitate another joint, which should be avoided.

Panelling the Complete Wall

If going to the height of the wall, a top banding or a capping, with the bullnosed edge downwards, creates a good finish.

Constant use should be made of the level in order to maintain true joint lines.

Synthetic Marble Ceilings

The tendency to have the ceilings covered with this synthetic marble is becoming popular as it departs from the proverbial white or light plain colours. One might be astounded to see a black polished ceiling with the white veining of *bleu-belge* or the high light-reflecting properties of *lex-sienna*, while a sky-blue with the graining of white as seen in the black-and-white St. Annes marble, would give a definite impression of loftiness. All these colours have been made and fixed, with really wonderful lighting effects.

Fixing Ceilings by the Solid Wet Method

The fixing of ceilings by the solid wet method is more difficult, and skilled men are required for this. For ceilings, the sheets are made $\frac{1}{8}$ in. thick with a fixing of $\frac{1}{8}$-in. solid cement backing.

If carefully carried out with sheets 18 in. square a very nice effect is obtained when polished.

The Dry Fixing Method

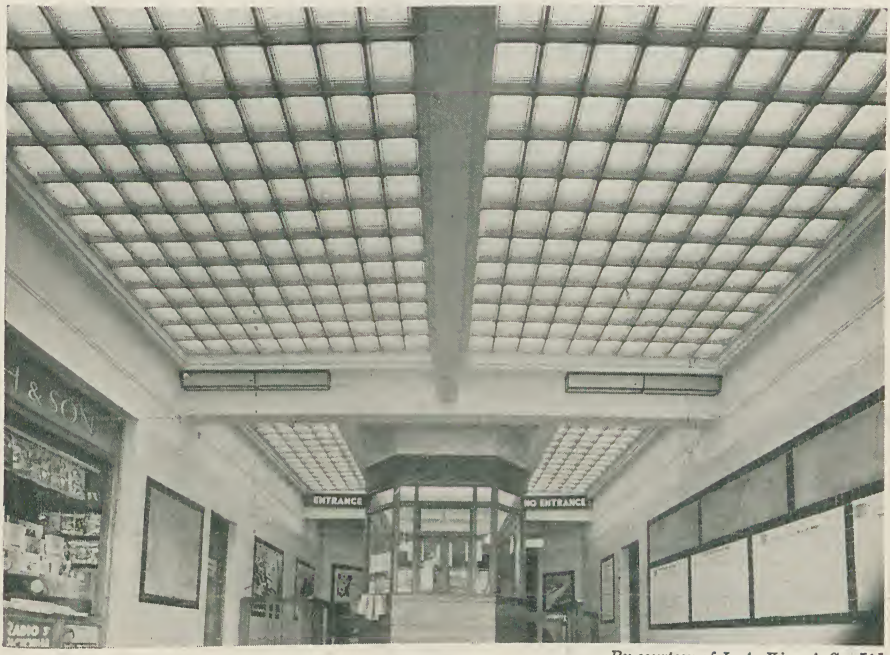
The dry fixing method, with panels 24 in. square and $\frac{1}{2}$ in. thick, consists of screwing the panels to strongly fixed wood battens, the edges being covered by a suitable wood or metal moulding, toned to match or contrasting finish.

Ceilings have now the greatest influence in decorative schemes, and one is visibly affected, so much so, that nerve complaints are known to have strong reactions.

For instance, if the walls of a room are lined with a certain Swedish green synthetic marble, and the ceiling finished off with a dove-grey introducing a suitable graining of a green and mauve, a person with tired and jaded nerves, on entering and closing the door, will experience a feeling of relaxation and relief almost instantly.

This nerve tension is influenced directly by these colour schemes, and architects are even collaborating with certain nerve specialists, who have made a study of these reactions.

PRESSED AND MOULDED GLASS



By courtesy of J. A. King & Co. Ltd.

Fig. 1.—Concrete-and-glass ceiling, Raynes Park station, Southern Railway

The upper lenses built into the concrete, and lower fixed to under side of bars, giving an insulating air space between outer and inner glasses.

GLASS is a new recruit to the ranks of modern building materials, although in the form of spun, blown, drawn, or rolled glass it has been employed for many years as a transparent material for filling windows and doors.

Pressed Glass

The invention of the process, however, whereby molten glass can be pressed and moulded into various shapes, definitely brings it into the ranks of those materials which perform constructive functions in modern buildings. Glass is widely employed to-day in two different functions. Structures such as the Crystal Palace (now destroyed by fire) or the Bauhaus at Dessau in Germany used vast areas of glass simply as window

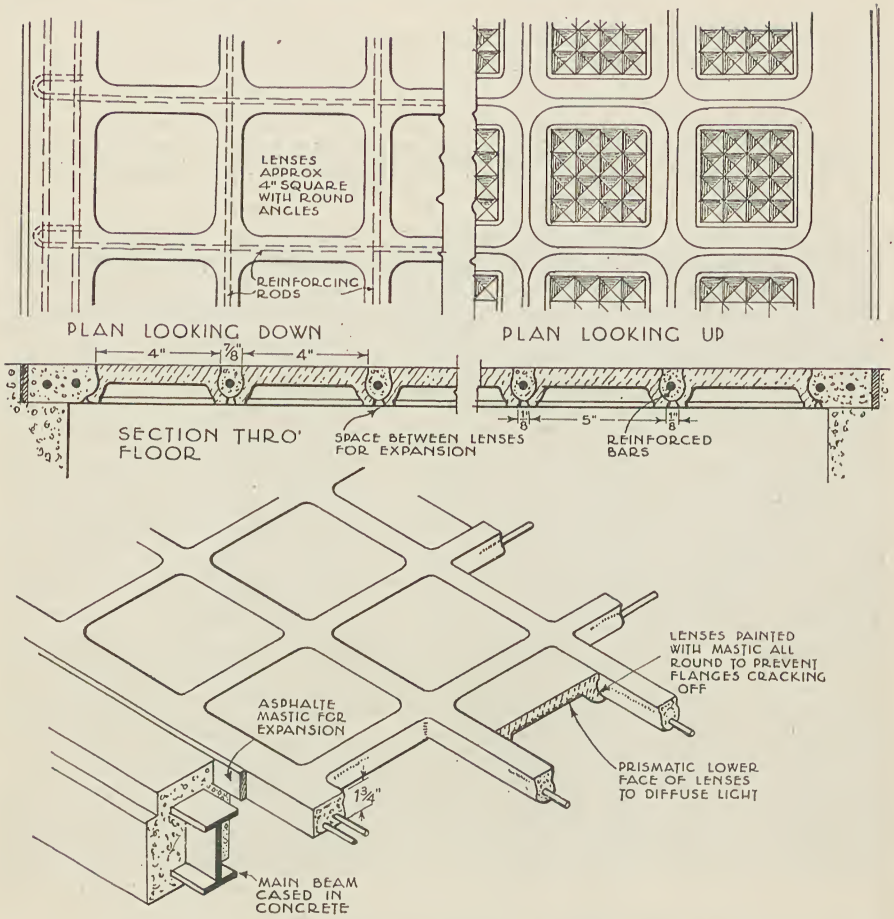


Fig. 2.—GLASS-AND-CONCRETE FLOOR, SHOWING MAIN BEAM

filling. The advance in design which makes the second function possible is in the steel-and-concrete structural support. It was the introduction of the reinforced-concrete pavement light filled with cast-glass lenses that really began the era of glass construction, for here both the materials perform structural functions. Modern glass floors and roofs are an extension of the principle of the pavement light.

Structural Principles

It is well known that in a reinforced-concrete floor slab the material is unstressed below the level of the reinforcing bars—all tension being taken up by the steel. Glass has a crushing strength equal to that of cement concrete ; the glass prisms can therefore be manufactured coffer-shaped to take up the compressive strain alone, which means a thickness

of between 1 in. and $1\frac{3}{4}$ in., with flanges the full depth of the slab.

Completely Enclosed Reinforcing Bars

Between 1908 and 1910 a system of floor prisms was invented in Germany, having the lower flanges bent round so as almost completely to enclose the supporting bars (Fig. 2). A small space is left, between each prism, about $\frac{1}{8}$ in. wide, to prevent the glass from cracking under temperature changes. But apart from these hair lines the whole ceiling, when seen from below, is translucent, as owing to the refraction through the lenses the supporting bars buried in the glass are almost invisible.

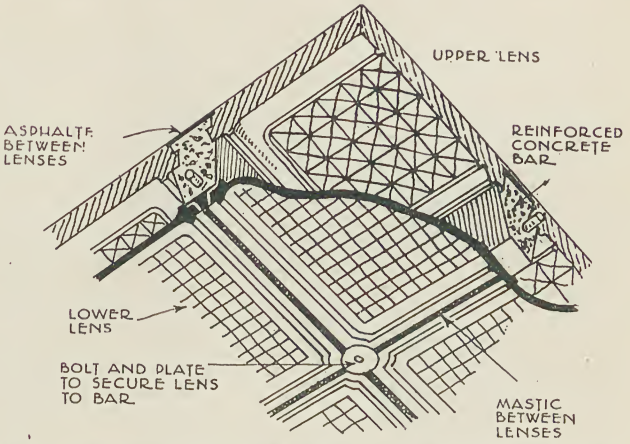


Fig. 3.—MODERN CONCRETE FLOOR AND CEILING WITH UPPER AND LOWER LENSES

Total thickness $3\frac{1}{4}$ in. Lenses $10\frac{1}{4}$ in. between centres of bars.

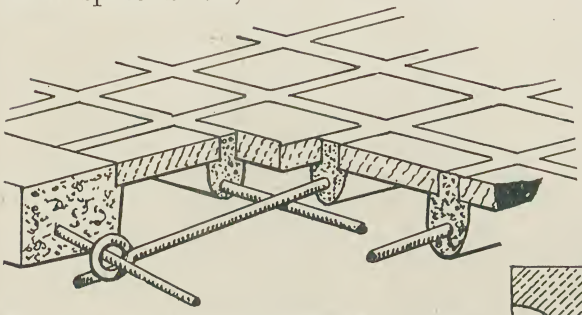


Fig. 3A.—REINFORCED-CONCRETE-AND-GLASS CEILING WITH CONCRETE BARS EXPOSED ON UNDER SIDE

Trouble has at times been experienced with these deep-flanged lenses, and some firms prefer to have a shallow upper lens without flanges, and to fix a second below it on the lower face of the concrete supporting-bars, the space between each square being filled with mastic (Fig. 3). This method insulates against sound

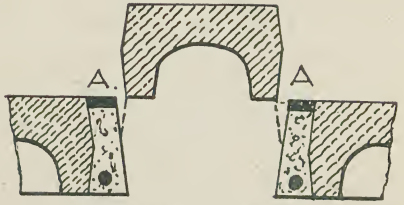


Fig. 4.—A METHOD OF FIXING LENSES WHICH ALLOWS REPAIRS TO BE EXECUTED FROM THE UPPER SIDE WITHOUT SCAFFOLD

Corners at A are chipped away and lens removed.

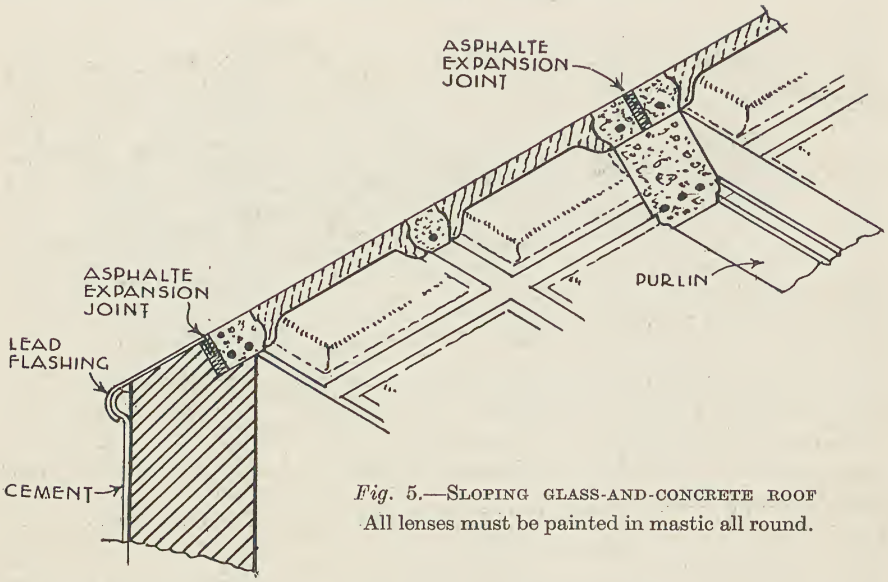


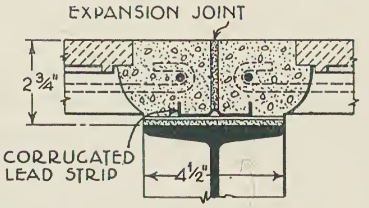
Fig. 5.—SLOPING GLASS-AND-CONCRETE ROOF
All lenses must be painted in mastic all round.

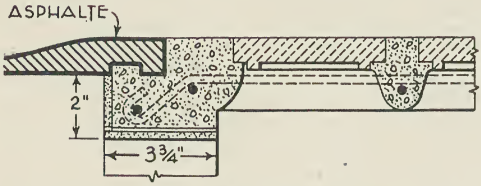
and temperature changes, and eliminates the possibility of condensation. Where these flangeless lenses are employed, the reinforced concrete has taken up practically all the stresses, but in this case the bars have to be stouter, and when looking up from below, the appearance of the black grillage of concrete against the bright glass is not always satisfactory (Fig. 3A).

Glass Roofs

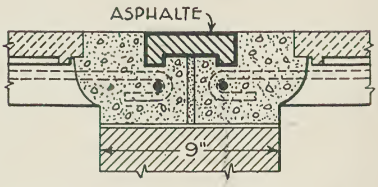
Roofing in glass and concrete can be either flat, barrel-vaulted, or pitched ; in the last case, for the best appearance the rise should be

Fig. 6.—VARIOUS TYPES OF JOINTING FOR GLASS PANELS
Right.—A.—Joint of panels over steel beam.

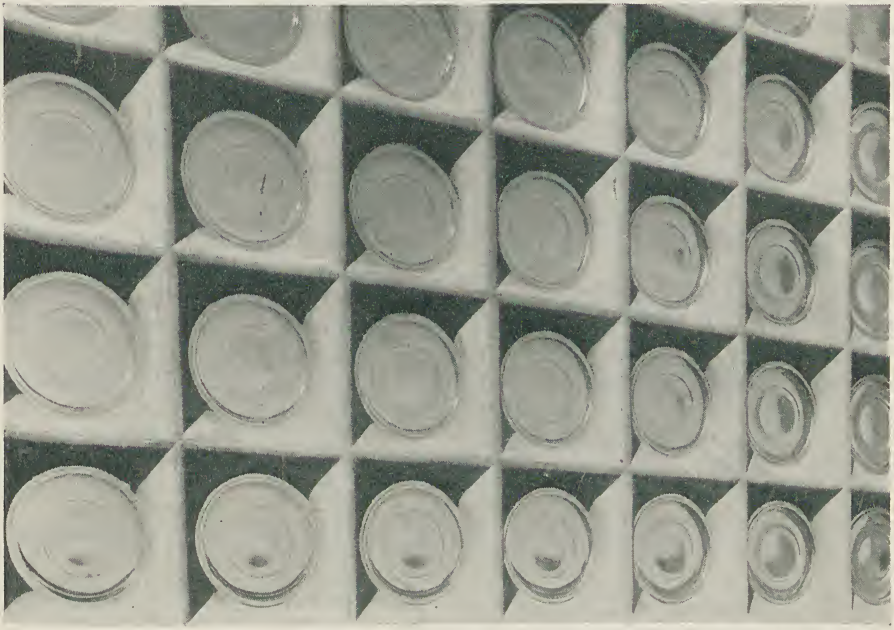




B.—Joint of glass and solid concrete roofs.



C.—Joint of panels over brick wall.



By courtesy of J. A. King & Co. Ltd.

Fig. 7.—CIRCULAR LENSES IN SQUARE CONCRETE FRAMES WITH CORNERS SPLAYED TO ALLOW OF MAXIMUM LIGHT. VIEW LOOKING UP

slight (Fig. 5). The material being homogeneous, it should be remembered that with either a curved or a pitched roof the thrust is almost negligible. One of the largest examples of flat-roof construction in this " transparent concrete " erected in England is the factory of Messrs. Boots at Beeston, where the packing hall is spanned by a concrete-and-glass roof 580 ft. long by 69 ft. wide. Each bay is divided by purlins spaced at 7-ft. 8-in. centres, and filled in with panels of concrete and glass $1\frac{3}{4}$ in. thick.

Sizes of Pressed-glass Prisms

All rectangular prisms used in these floors and roofs must have rounded corners, as under certain conditions the square edges are liable to fracture. The usual sizes of prisms are from 5 in. sq. up to 10 in. sq., and the thicknesses vary from 1 in. to $1\frac{3}{4}$ in. For floors with constant pedestrian traffic, lenses should not be more than 5 in. sq., to avoid risk of slipping.

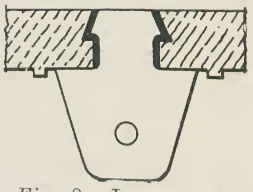
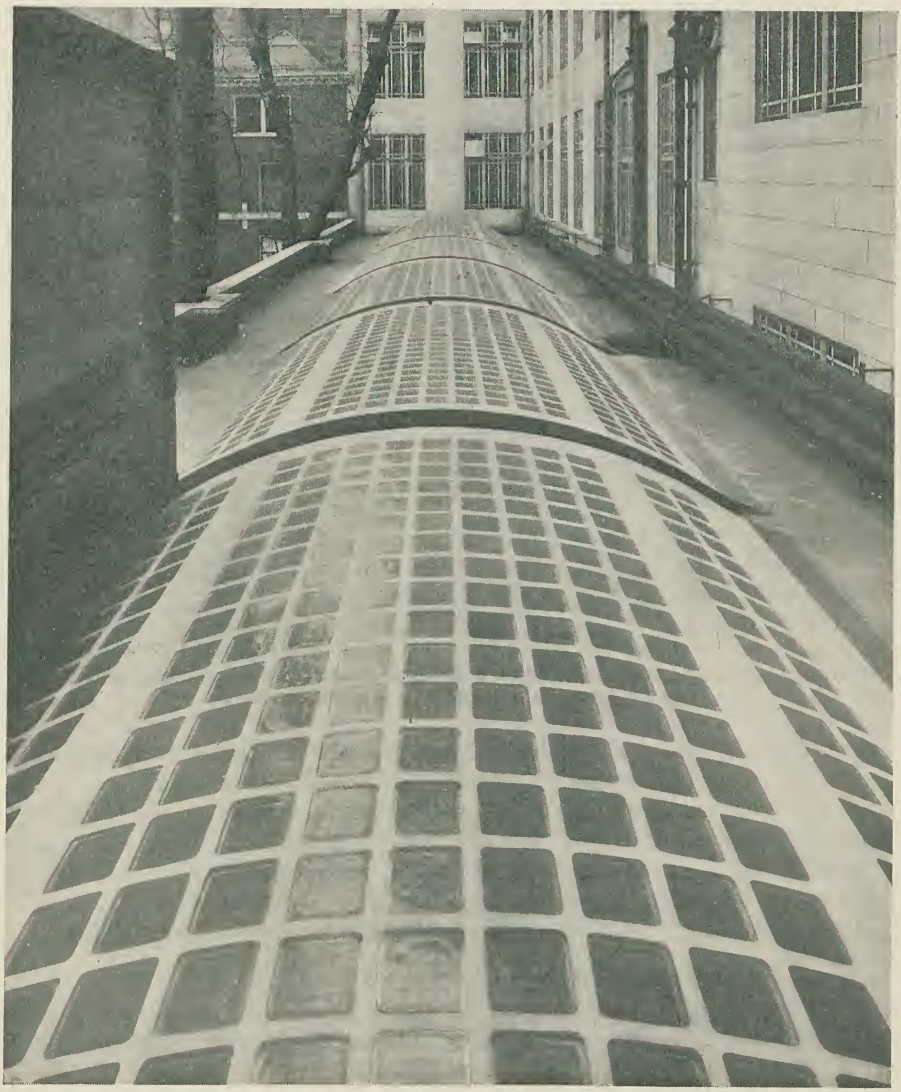


Fig. 8.—LENSES INSULATED TO THEIR FULL DEPTH WITH MASTIC COMPOUND

Insulation of Prisms in the Concrete

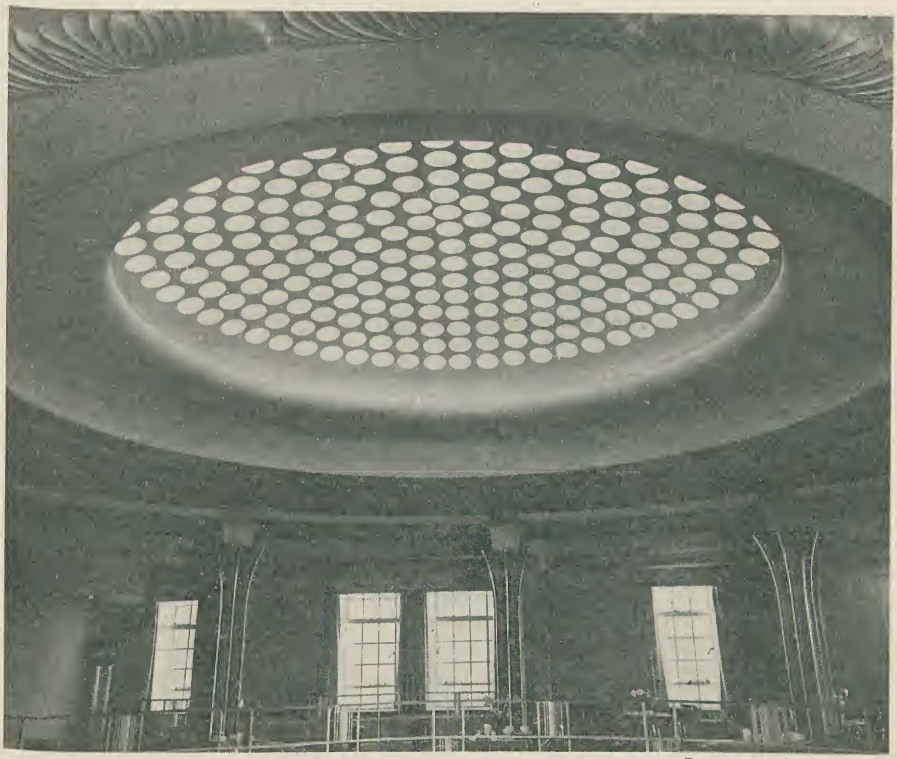
All large, flat areas should be provided with asphalte or other mastic jointing between the concrete slabs, and special care taken where these



By courtesy of J. A. King & Co. Ltd.

Fig. 9.—BARREL VAULT IN CONCRETE AND GLASS—NO. 3 ST. JAMES'S SQUARE, LONDON

joints occur over steel beams (Fig. 6A). A good method is to lay a piece of corrugated lead below the concrete immediately over the joint. Before placing the lenses, they should be insulated by painting the edges and coating them with a bituminous preparation, which is often a special material supplied by the makers (Fig. 8).



By courtesy of Lenscrete Ltd.

Fig. 10.—THE MAJESTIC CINEMA, EAST GRINSTEAD

Concrete-and-glass dome over rotunda composed of large 8-in. lenses set on the centering with the reinforcing rods, and the concrete poured round them.

Circular Lenses

Circular lenses, of varying diameter from 5 in. to 10 in., are used in a similar manner to rectangular. In this case the lenses rest upon the usual concrete members which form the supporting mesh, but these members are sharply cut away on the under side to allow of the passage of the maximum amount of light. These circular lenses are also used for domes and vaults, but the large domes filled with an enormous number of small lenses, some 4 in. deep, are not so common in this country as in France, where they are manufactured at the St. Gobain glass works.

Constructing a Glass-and-concrete Dome

In constructing a glass-and-concrete dome, the wood shuttering is first erected in position from below. This is then covered with a coat of plaster of Paris carefully smoothed to the exact shape of the dome. On this is marked with string the position of each lens, which is then put

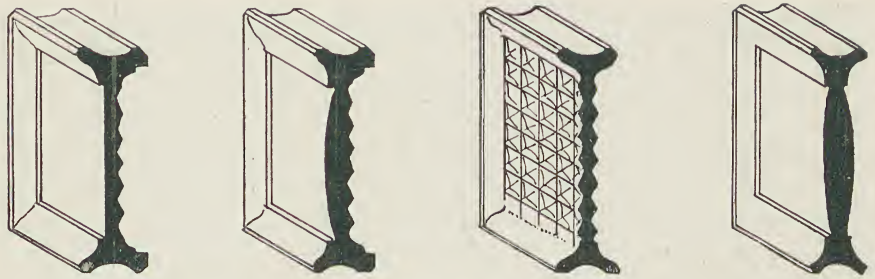


Fig. 11.—VARIOUS TYPES OF PRESSED-GLASS LENSES USED FOR GLASS WALLS

accurately in place and held fast by small tacks round its lower flange. To prevent the upper faces becoming obscured with concrete splashings, these are covered with a gummed paper before the first layer of concrete is worked in between them. When this first layer has been thoroughly trowelled all round the lenses and pressed down firmly, the reinforcing rods are laid and tied into position. The second layer of concrete is then poured in, consolidated, and finally smoothed off level with the tops of the lenses. When the initial set has taken place, the outer surface is rubbed over, the gummed paper removed, and all irregularities filled in. Later, the centering below is struck, and the plaster-of-Paris mould removed.

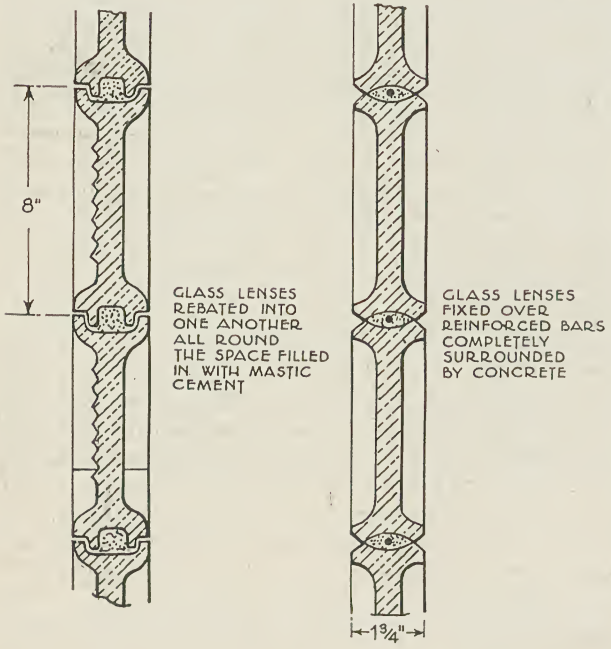
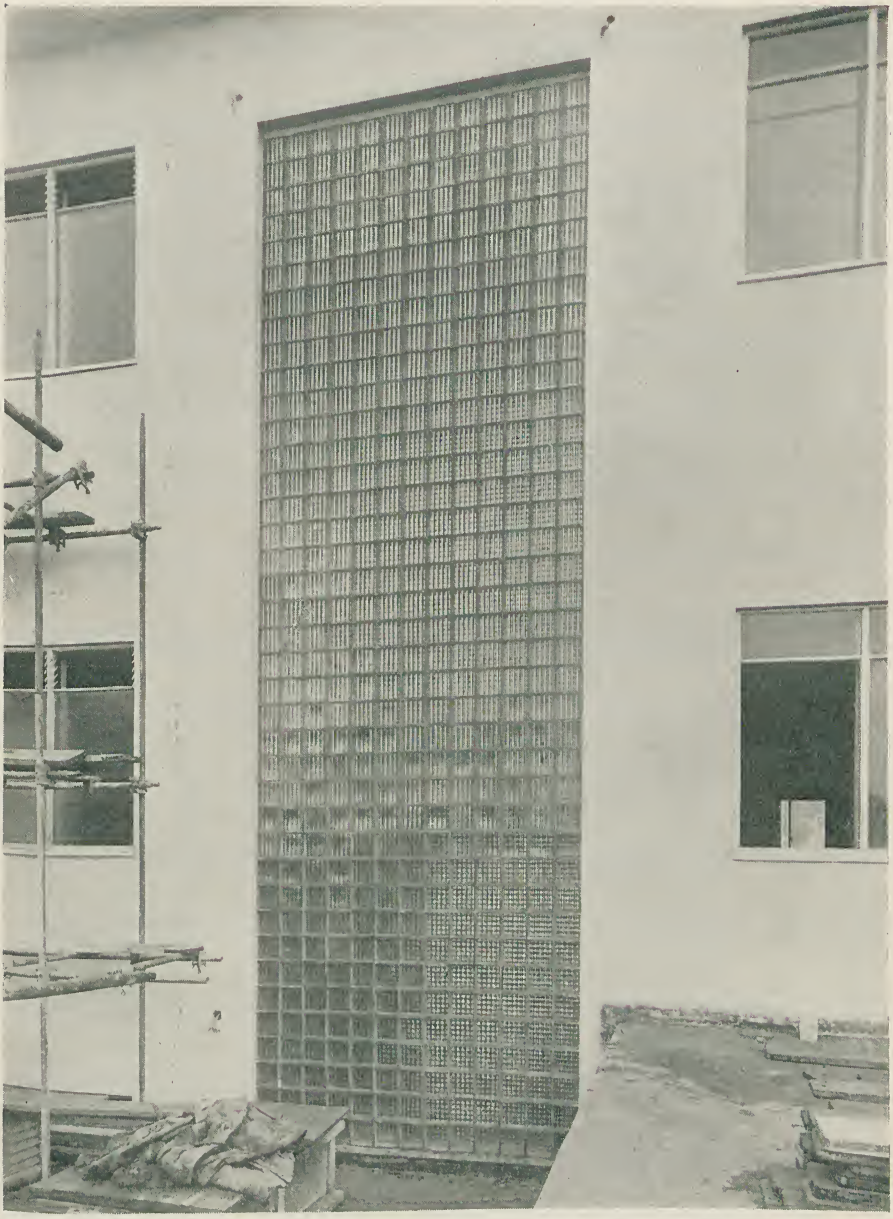


Fig. 12.—TWO METHODS OF BUILDING GLASS WALLS WITH PRESSED-GLASS LENSES

Glass Walls

The construction of glass walls differs but slightly from that of floors, for in these cases the tensional stresses on large areas of concrete and glass are set up by wind pressure. The best form of glass walling resembles an enormous window opening, filled in with a light rectangular grille of reinforced-



By courtesy of Lenscrete Ltd.

Fig. 13.—DENHAM FILM STUDIOS

Wall of laboratory, composed of concrete and glass. The thin concrete frame is reinforced with steel rods, and the glass lenses are moulded with prisms to refract the light.

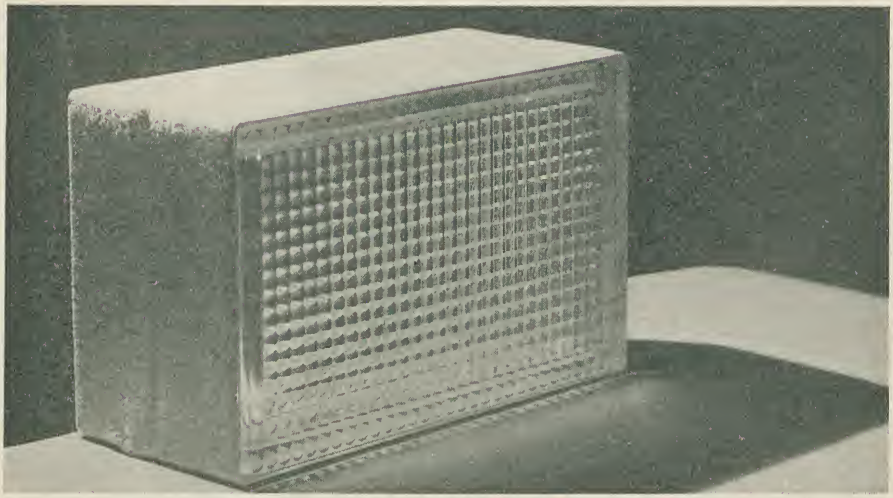


Fig. 14.—GLASS BRICK FORMED WITH TWO LENSES ANNEALED TOGETHER AND SANDED ON THE SIDES

The surface is divided into convex ribs, run vertically on outside and horizontally on inside. Size of brick, 8 in. by $4\frac{7}{8}$ in. by $3\frac{7}{8}$ in. (*By courtesy of Pilkington Bros. Ltd.*)

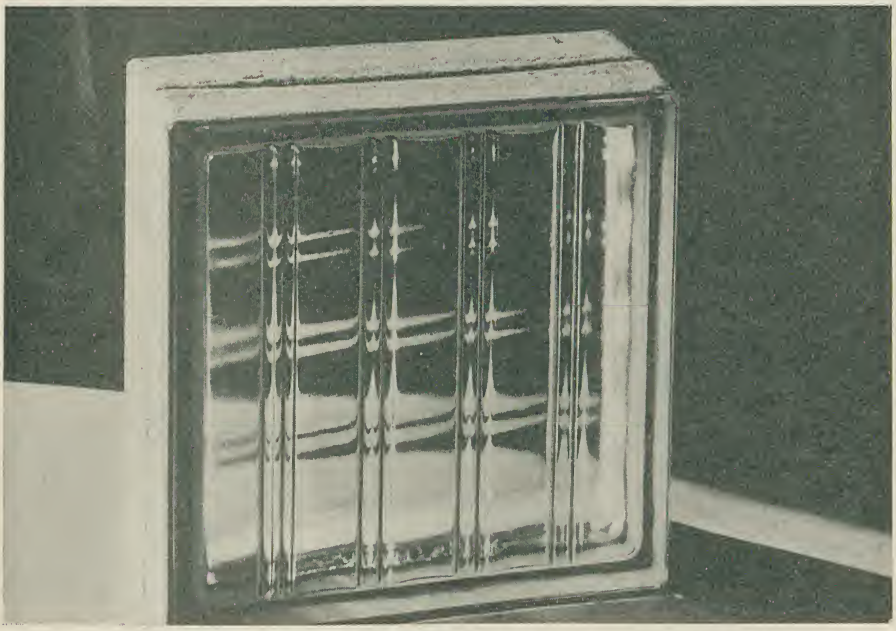


Fig. 15.—GLASS BRICK OF SQUARE SHAPE FORMED OF TWO LENSES ANNEALED TOGETHER

Each lens has a $1\frac{1}{2}$-in. concave rib, running vertically on one and horizontally on the other. The ribs are placed on inner faces, leaving outside of glass smooth. Size of brick, $7\frac{3}{4}$ in. by $7\frac{3}{4}$ in. by $3\frac{7}{8}$ in. (*By courtesy of Pilkington Bros. Ltd.*)

concrete bars. Into this grillage the glass prisms are fitted, the prisms themselves being cast in special shapes to diffuse the light into the interior through vertically standing lenses, in place of the horizontal type employed in floorings (Fig. 11). The most usual shape is one resembling a rolled-steel beam in section, with a flange top and bottom which is hollowed so as almost to enclose the concrete bar. Smaller areas sometimes have the lenses themselves rebated on the flanges so that they fit one into another (Fig. 12). All these shaped lenses evince a tendency to crack unless well insulated from the concrete surround with mastic compound, and recent experiments tend to favour the adoption of a moderately thin lens let into a concrete rebate. This shape is not so likely to crack, and even if it does so, is easy to renew.

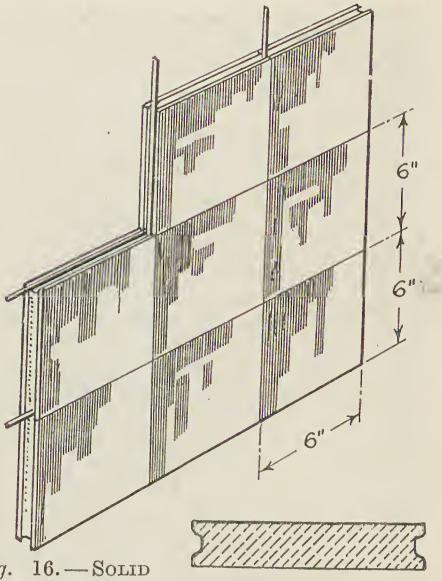


Fig. 16.—SOLID GLASS BRICK PARTITION WITH REINFORCING RODS, BOTH HORIZONTAL AND VERTICAL

Fig. 17.—SECTION OF SOLID GLASS PARTITION BRICK

Internal Glass Partitions

Other forms, used for internal partitions, are constructed of glass slabs hollowed round the edges. These squares are about 6 in. by 6 in., and to erect require both horizontal and vertical reinforcing bars as stiffeners (Fig. 16).

Another type of glass wall is composed of lenses placed in pairs vertically, and rebated one over the other round reinforcing bars. This method allows an air space between the lenses, which provides adequate insulating

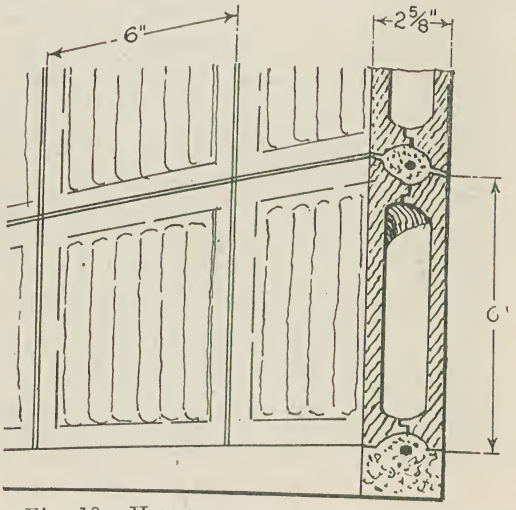


Fig. 18.—HOLLOW GLASS PARTITION WALL

Showing wall composed of lenses jointed over reinforced-concrete bars. The bottom is composed of a reinforced bar laid direct to floor. Stresses are not transferred from outer to inner lenses.

By courtesy of Lenscrete Ltd.

Fig. 19.—WAITING-HALL OF VERSAILLES RAILWAY STATION

Roof barrel vaulted in concrete and glass. The lenses are let in flush with both inner and outer surfaces of the concrete, to obtain the maximum amount of light.

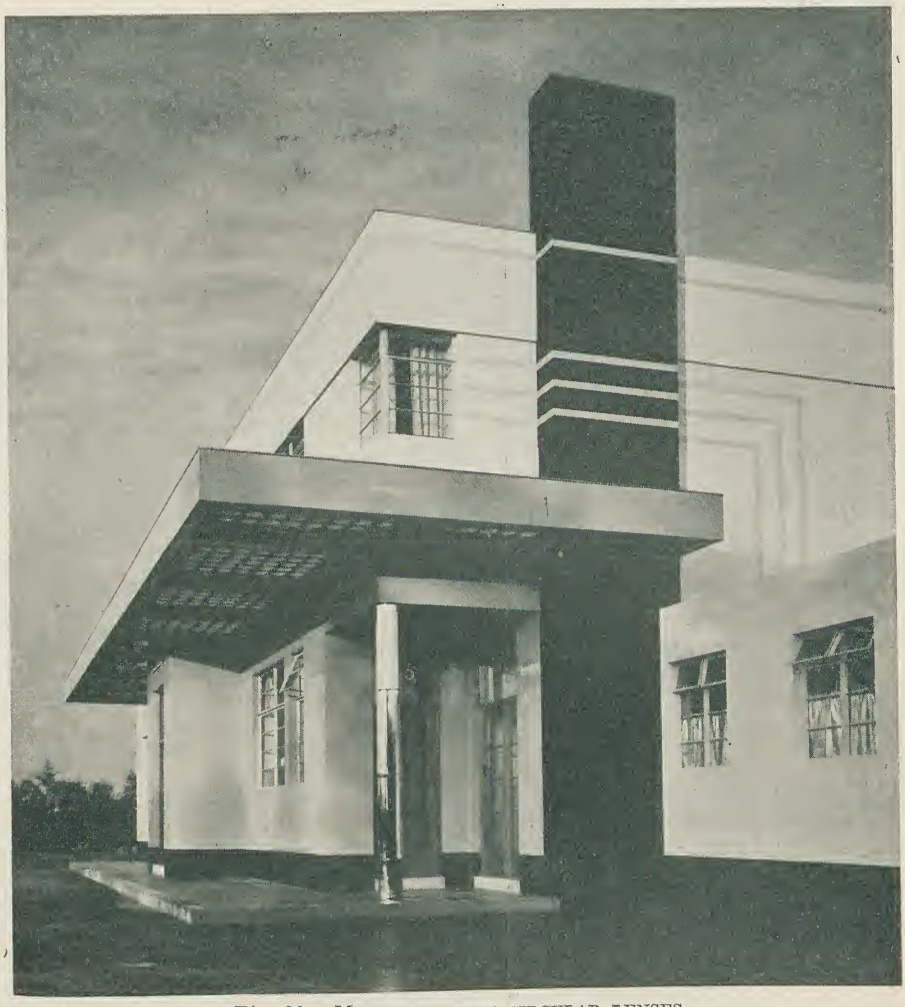


Fig. 20.—MARQUISE WITH CIRCULAR LENSES

Showing new hotel at Kirk Sandall, Doncaster, for Messrs. Pilkington Bros. Ltd. The building itself illustrates the application of glass as a facing to a structure consisting of brick with reinforced-concrete floors, the glass facings being opaque and in various colours (vitrolite). (*Architects: T. H. Johnson and Son, F/A.R.I.B.A.*)

properties when employed over large areas (Fig. 18). Another advantage of this method of construction is the slight amount of play existing between the lenses, so that changes of temperature acting on the outer one do not set up strains in the glass of the inner.

Glass Bricks

One method of actually building in glass is to employ glass bricks, which are really hollow cast-glass tanks. These are placed one on

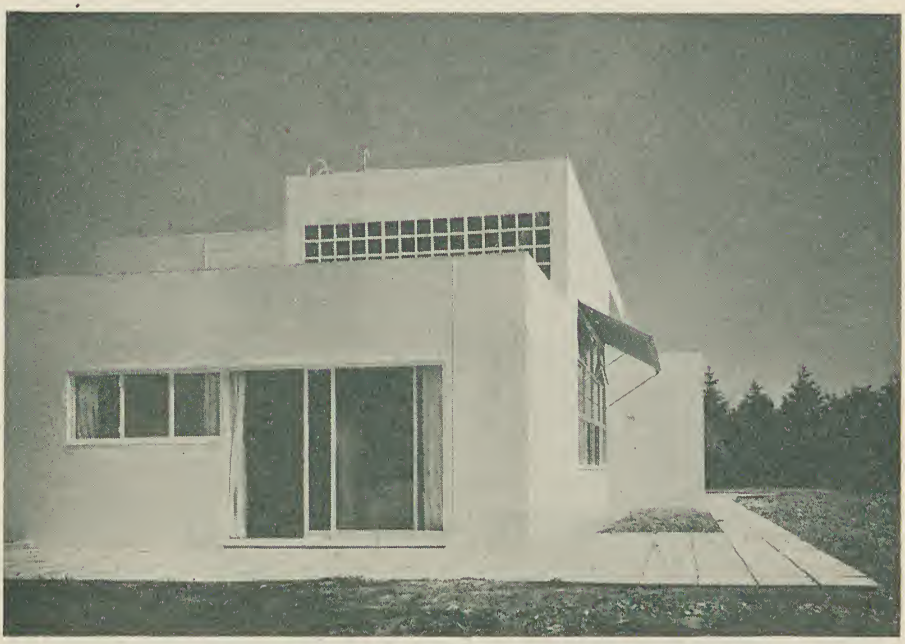


Fig. 21.—AN EXAMPLE OF THE USE OF CONCRETE-AND-GLASS WALL IN HOUSE CONSTRUCTION

A house at Hatfield, with lenscrete windows high up in a part of the living-room, which extends to the roof. The plan of this house is given in Vol. I, page 159. Fig. 23 shows a view inside the room. (*Architect: F. R. S. Yorke, A.R.I.B.A.*)

another, the open end downward, and each brick is prevented from slipping sideways off the one below by means of projecting flanges cast on to the brick. The vertical joints are broken as in ordinary brick building. Such bricks are suitable only for internal work, and must be carefully insulated by either asbestos or mastic (Fig. 22).

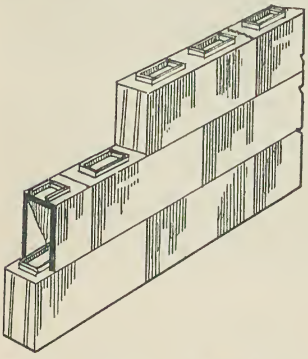


Fig. 22.—HOLLOW GLASS BRICK PARTITION

Solid glass bricks, known as Insulite, with prismatic faces, are now made, which can be built into walls or used in a variety of ways. These bricks are good light-transmitters and diffusers, owing to the variations of the surfaces. They are obtainable at present in this country in three sizes, viz.: 8 in. by $4\frac{7}{8}$ in. by $3\frac{7}{8}$ in. thick; $7\frac{3}{4}$ in. by $7\frac{3}{4}$ in. by $3\frac{7}{8}$ in. thick; and $5\frac{3}{4}$ in. by $5\frac{3}{4}$ in. by $3\frac{7}{8}$ in. thick. Each brick really consists of two lenses annealed together while warm. The annealed edges are afterwards sand-blasted and roughened to take the fixing cement. Two of these types have serrated

Photo: "Architect & Building News"

Fig. 23.—LIVING-ROOM OF HOUSE AT HATFIELD

This shows part of the living-room of the house illustrated in Fig. 21, looking from beneath the concrete-and-glass wall. Note how it has been possible to enliven the interior by arranging for part of the room to extend to the roof—an example of treatment for those requiring the stimulation of contrasting forms in their homes, referred to on page 160, Vol. I. (*Architect: F. R. S. Yorke, A.R.I.B.A.*)

or ribbed external faces, and the other is smooth. The bricks possess a high insulating property, owing to the partial vacuum inside each, and transmit from 84 per cent. to 73 per cent. of light. The edges are sanded for building in cement, and when the wall or partition is complete it has all the sanitary properties of sheet glass. They are useful in constructional work such as dairies, hospitals, stores, and industrial buildings where light is essential, but divisions must be sound- and heat-proof. Further advances in this type of building will lead to further types of bricks being put on the market, and already a large American glass brick has been offered, made by the Pyrex glass firm, but the cost of building in this material is high.

In all glass-and-concrete structures the most important matter is the proper insulation of the prisms with bituminous compounds, usually supplied by the makers, and the architect should see that this compound is one that remains permanently elastic. Glass will often behave quite

well for several years and then the lenses begin to crack and spall, especially if they are of a type with exceptional thickness of glass in places. A small, flat shape is nearly always to be preferred to one with deep flanges or ribs. Prime cost is not the first consideration, as work that is going to last must be carefully done, and it is the many small processes which the best firms employ which will make the work reasonably permanent.

QUESTIONS AND ANSWERS

What are the objects of using a Double Layer of Glass-and-concrete Construction for Floors and Ceilings ?

(1) To avoid trouble from deep-flanged lenses in a single layer.
(2) To insulate against sound and temperature changes.
(3) To eliminate condensation.

What forms of Roofing are possible with Glass and Concrete ?

Flat, barrel-vaulted, and pitched. In the case of pitched roofing the rise should be slight, to obtain the best appearance.

Why must rectangular Prisms used in Floors and Roofs have Rounded Corners ?

Because, under certain conditions, square edges are liable to fracture.

What are the usual Sizes of Prisms for Floors and Roofs ?

Five inches square up to 10 in. square. For floors with constant pedestrian traffic, lenses should not be more than 5 in. square, to avoid risk of slipping.

How are Circular Lenses arranged ?

In the same manner as rectangular lenses. Circular lenses rest upon the usual concrete members, which form the supporting mesh, but these members are cut away sharply on the under side to allow of the passage of the maximum amount of light.

What procedure is adopted in constructing a Glass-and-concrete Dome ?

The wood shuttering is first erected in position from below. It is then covered with a coat of plaster of Paris carefully smoothed to the exact shape of the dome. The position of each lens is marked on this with string, and the lenses put accurately in place and held fast in place around their lower flanges. The upper faces are covered with gummed paper before the first layer of concrete is worked in between them, to prevent the upper faces becoming obscured with concrete splashings. When the first layer has been thoroughly trowelled all round the lenses, and pressed down firmly, the reinforcing rods are laid and tied into position. The second layer of concrete is then poured in, consolidated, and finally smoothed off level with the tops of the lenses. When the initial set has taken place, the outer surface is rubbed over, the gummed paper removed, and all irregularities filled in. Later, the centering below is struck, and the plaster-of-Paris mould removed.

PRACTICAL NOTES ON REINFORCED CONCRETE

IN reinforced concrete, perhaps more than any other form of construction, it is important to realise the responsibility which rests on the practical man in charge of the job. Modern research has shown that, with proper control and supervision, concrete can be produced with safe working stresses much in excess of those in general use to-day. This can only be done, however, by training craftsmen in concrete, having a thorough understanding of the properties of the material, and taking a pride and interest in their work. The proposed Code of Practice drawn up by the Reinforced-concrete Structures Committee of the Building Research Board takes this into consideration by allowing for three grades of concrete: ordinary grade, high grade for work with constant supervision, and special grade, in which the concrete may be stressed in proportion to the strength actually obtained, and in which the standard is maintained by means of constant tests. If this code is generally adopted, there will be a definite incentive to produce better-quality work.

To the practical man, it is necessary to point out that the strength of concrete depends, not only upon the quality of cement and aggregates, but also upon the quantity of water used in mixing, the thoroughness of mixing, and the care taken in placing and consolidating in position. In fact, using the same materials, it is possible for the concrete to vary in strength by as much as 50 per cent. when made by different gangs.

MATERIALS

General

It is obviously impossible to make good concrete unless sound materials are used. Not only must the materials be sound when they are delivered on to the site, but proper care must be taken to see that no deterioration takes place before they are used in the work. The quality of steel and cement is usually specified by the engineer or architect, but the quality of sand, coarse aggregate, and shuttering is often left to the clerk of works or the contractor. Samples of sand and coarse aggregate should be submitted for approval before ordering in bulk, and works test certificates should be obtained for all consignments of cement and steel. These are usually called for by the engineer responsible for the work. Cement should be stored in a weatherproof shed with raised floor, and should not be removed until required for mixing. Steel reinforcement should be

stored off the ground, and put under cover if left on the site for any considerable length of time.

Cement

It is usual to specify that Portland cement shall be in accordance with the British standard specification, but the manufacture of cement has so improved in recent years that the quality produced by most reliable manufacturers—in this country, at any rate—is far in excess of that demanded by the British standard specification. The following table shows the increase in strength called for by the various issues of the British standard specification, and also the strength it is possible to obtain with a reasonably good cement to-day.

TABLE I

INCREASE IN STRENGTH CALLED FOR BY THE VARIOUS ISSUES OF THE BRITISH STANDARD SPECIFICATION

	Tensile Strength (*lb./sq. in.*)					*Residue on 180-mesh Sieve*
	Neat		3 : 1 *Mortar*			
	7 *days*	28 *days*	3 *days*	7 *days*	28 *days*	*per cent.*
B.S.S., 1904	400	500	—	120	225	22·5
„ 1907	400	500	—	150	250	18
„ 1910	400	500	—	150	250	18
„ 1915	450	538	—	200	250	14
„ 1920	450	538	—	200	250	14
„ 1925	600	—	—	325	356	10
„ 1931	—	—	300	375	—	10
Good modern cement	900	1,150	450	650	800	5

Cement soon deteriorates if left exposed, and it is therefore advisable to obtain it fresh from the works as required; old or lumpy cement should never be used for good-class work.

Rapid-hardening cement is Portland cement subjected to extra-fine grinding, which does not affect the setting time to any great extent, but accelerates the hardening process.

Aluminous cement has a different chemical composition from Portland cement, and the two should never be mixed.

Sand

Sand for reinforced-concrete work should be clean, well graded from $\frac{1}{4}$ in. diameter down to dust, and consist of hard, non-porous particles.

The most common sources of supply are by dredging from rivers, digging from pits, and artificially producing by crushing rock and screen-

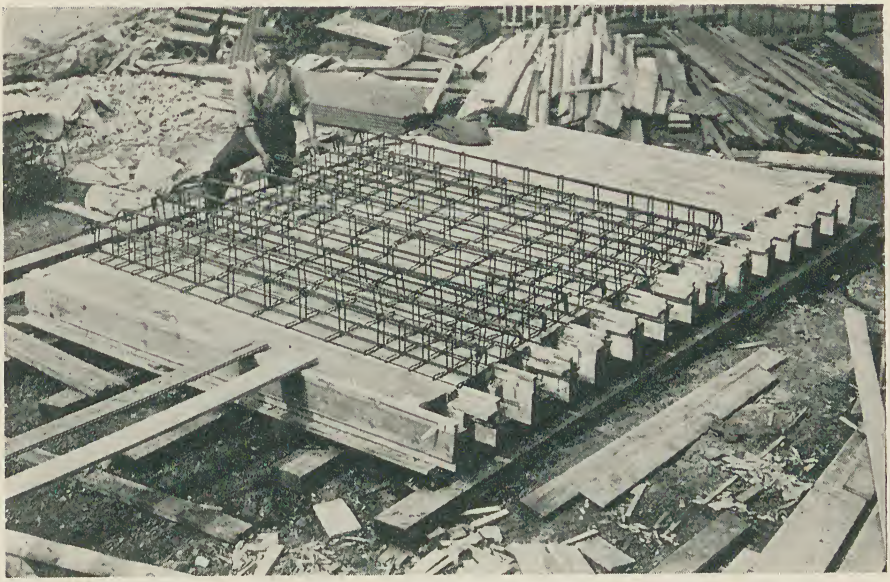


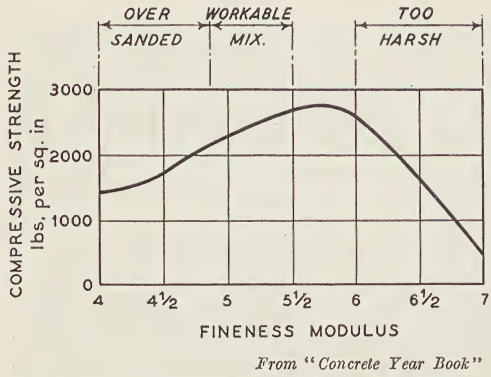
Fig. 1.—PRECAST FLOOR UNITS IN PROCESS OF MANUFACTURE FOR THE WALTHAMSTOW STADIUM

(*Reinforced concrete engineers : John Liversedge & Co.*)

ing out the fine material. This last method provides a very satisfactory sand, providing the rock is of good quality. Pit sand varies considerably in quality, and should always be subjected to careful examination and tests. River sand is more reliable, but should always be tested if there is any doubt as to quality. Impurities may consist of clay, organic matter, chalk, lime, or coal, etc., and of these, the first two are the most common sources of trouble.

To test for clay, mix a fair sample of sand with about two volumes of water in a glass jar, well stir, and allow to settle. The sand grains will rapidly fall to the bottom, leaving the clay in suspension. Allow to stand until the liquid has cleared, when the clay will have been deposited as a thin layer on top of the sand. If the silt exceeds 5 per cent., the sand should not be used.

To test for organic matter, take one volume of sand and mix thoroughly with two volumes of a 3 per cent. solution of caustic soda in a glass vessel. Allow to stand for 24 hours, when the presence of organic matter will be indicated by a brown discoloration of the solution. If this is darker than straw colour, then the sand should not be used without further analysis. The effect of organic matter is to retard the setting of the concrete, with possible disintegration. In all cases where there is any doubt as to the quality of either sand or coarse aggregate, samples



From "Concrete Year Book"

Fig. 2.—COMPRESSIVE STRENGTH OF CONCRETE

should be submitted for expert examination in a laboratory.

Coarse Aggregate

The essential properties of any aggregate for reinforced-concrete work are that it shall be clean, hard, suitably graded, weather-resisting, and inert in the presence of water and cement. For ordinary work, gravel or crushed stone is generally used, and in this country, at any rate, good local materials are usually available, and economic considerations will determine to some extent the material to be used. The particles should be round or cubical in shape, and well graded between $\frac{1}{4}$ in. and $\frac{3}{4}$ in. in size, except in special cases where a larger or smaller aggregate may be called for.

As with sand, it is important that coarse aggregate should be free from clay, organic matter, or chemical impurities. Sulphur is especially harmful, and for this reason, coke breeze or clinker should not be used. Furnace slag is also liable to contain injurious chemicals, and should only be used after satisfactory tests have been made. Broken bricks make quite a satisfactory aggregate providing the bricks are of good quality, well burnt, and free from lime mortar, plaster, or building debris.

The properties of the resultant concrete will depend to a large extent upon the quality of the aggregate. Thus, for watertight work, the particles should be smooth and close-grained; for wearing surfaces, they should be hard and resist abrasion; and for fireproof work, they should be stable under heat.

Grading and Proportioning Aggregates

A good deal of investigation has been carried out on the grading of aggregates with a view to producing dense, hard concrete with a minimum of cement. As the cost of Portland cement is usually five or six times the cost of aggregates per ton, it will be seen that any saving in cement is of economic importance.

The ideal aggregate is one in which the particles vary uniformly in size from dust to the maximum. In order to give a standard measurement of grading, the following method has been evolved and is largely advocated in the United States. A representative sample of the material is passed successively through a series of sieves having 100, 50, 30, 16, 8, 4, $2\frac{2}{3}$, $1\frac{1}{3}$, and $\frac{2}{3}$ openings to the linear inch. The weight of material

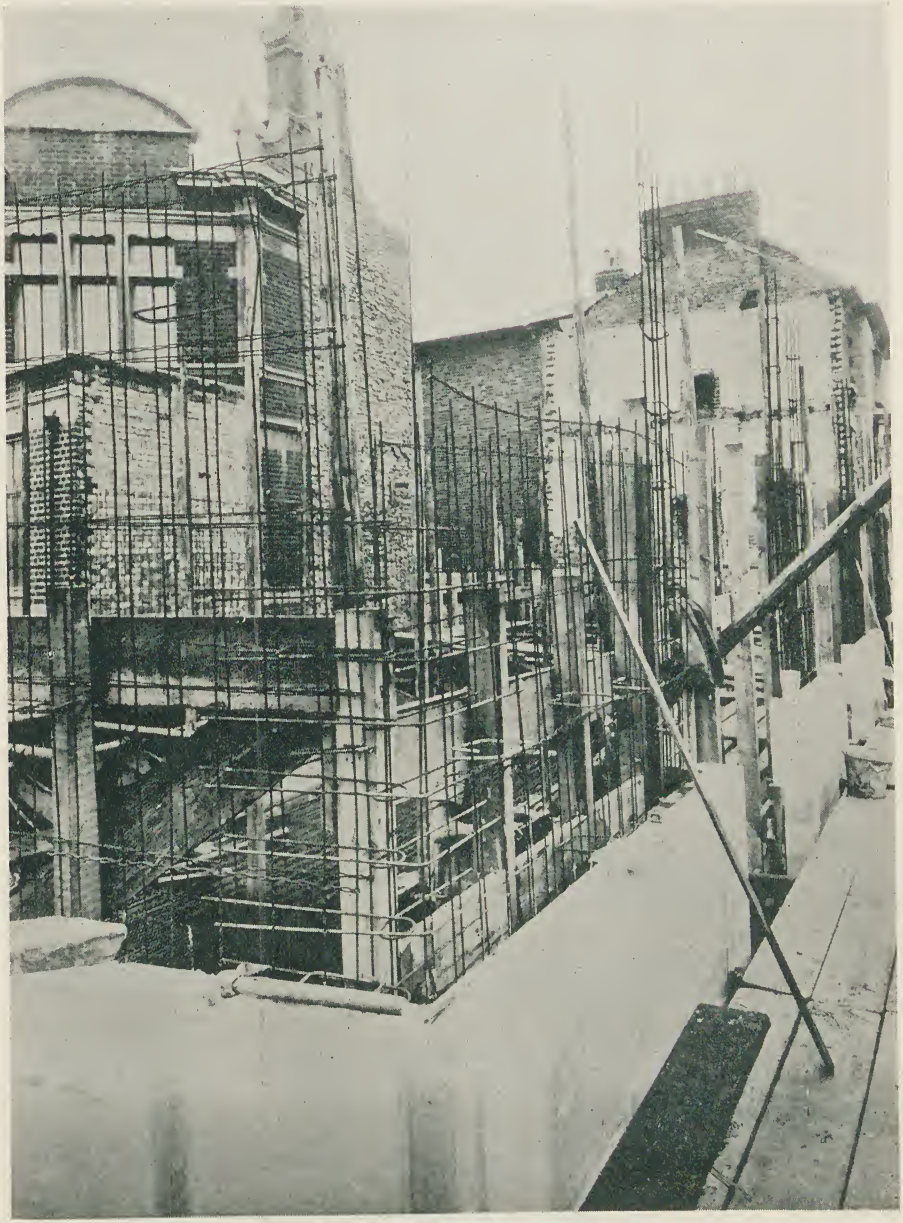


Fig. 3.—REINFORCEMENT FOR NATIONAL PROVINCIAL BANK BUILDING, EALING
(*Reinforced concrete engineers : John Liversedge & Co.*)

retained on each sieve is measured and put down as a percentage of the total weight, thus :—

Retained on	100	sieve	.. ..	97	per cent.
,, ,,	50	,,	.. ..	95	,, ,,
,, ,,	30	,,	.. ..	90	,, ,,
,, ,,	16	,,	.. ..	80	,, ,,
,, ,,	8	,,	.. ..	75	,, ,,
,, ,,	4	,,	.. ..	65	,, ,,
,, ,,	$2\frac{2}{3}$	,,	.. ..	40	,, ,,
,, ,,	$1\frac{1}{3}$	,,	.. ..	20	,, ,,
,, ,,	$\frac{2}{3}$	,,	.. ..	0	,, ,,
			Total	562	

$$\text{Fineness Modulus} = \frac{562}{100} = 5{\cdot}62$$

Experiments show that the compressive strength of the concrete varies with the fineness modulus somewhat as shown in the diagram (Fig. 2) for any particular mix.

If the fineness moduli of the sand and coarse aggregate taken separately are A and B respectively, then the proportion of sand R necessary to give any required fineness modulus M in a mixture of the two is given by the ratio :—

$$R = \frac{A - M}{A - B}$$

This method will usually give a smaller percentage of sand than is generally used, and it is safer to have too much sand rather than too little.

In this country, the general practice is to specify that the concrete shall be mixed with certain proportions of cement, sand (dust to $\frac{1}{4}$ in.), and coarse aggregate ($\frac{1}{4}$ in. and over). To obtain a dense concrete, it is necessary for the cement to fill the voids in the sand, and for the cement and sand mortar to fill the voids in the coarse aggregate. As the voids do not usually exceed 40 per cent. in either case, it will be seen that the standard 1 : 2 : 4 mix fulfils this condition with a reasonable margin of safety. With properly graded materials, the voids may be as low as 30 per cent., and a corresponding saving in cement could, therefore, be made. It is usual to specify that not more than 10 per cent. of the sand shall pass a 180-mesh sieve, and not more than 25 per cent. shall pass a 50-mesh sieve.

Water

The water for concrete should be clear and reasonably free from chemical impurities. Sea-water does not appear to have much effect upon the strength of the concrete, but is liable to cause efflorescence.

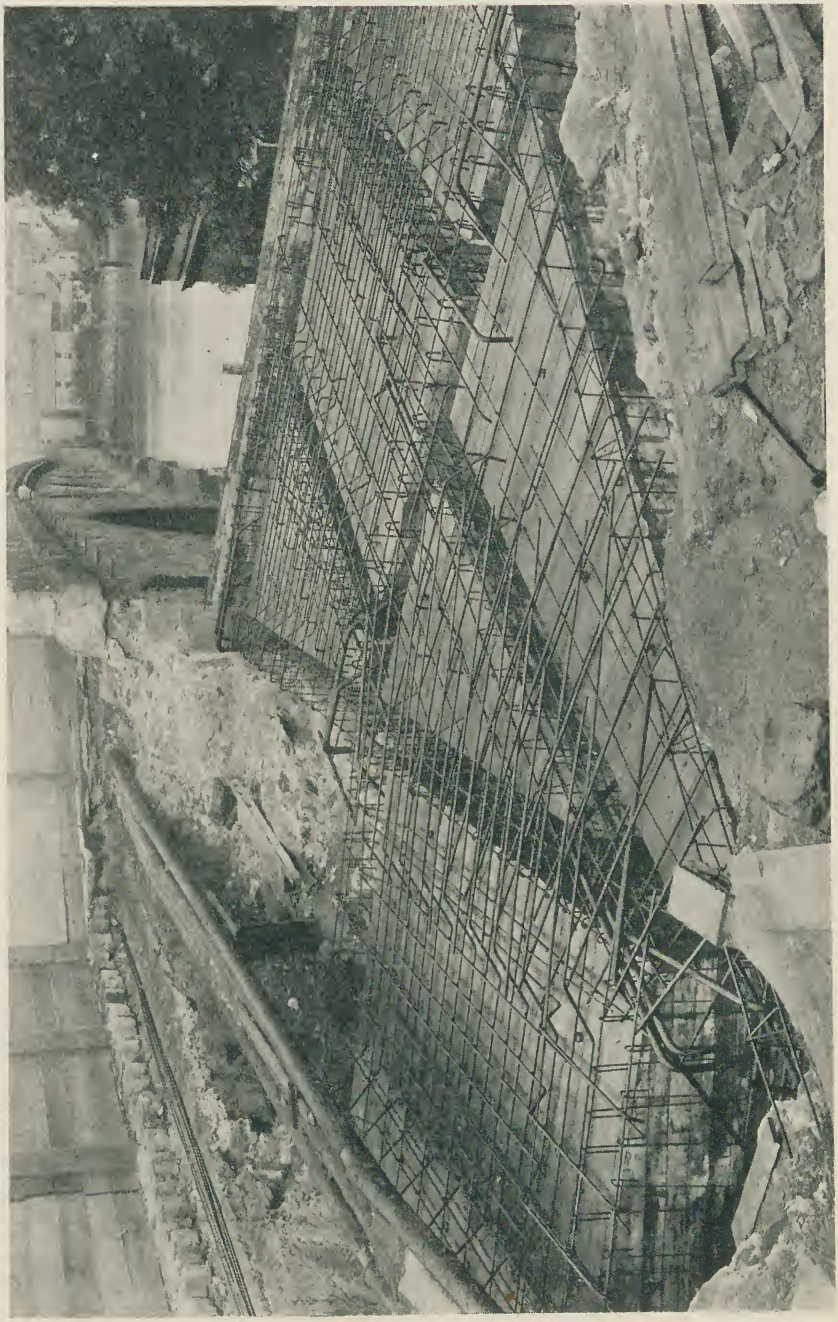


Fig. 4.—REINFORCEMENT FOR BRIDGE WIDENING, PERTH. (*Reinforced concrete engineers: John Liversedge & Co.*)

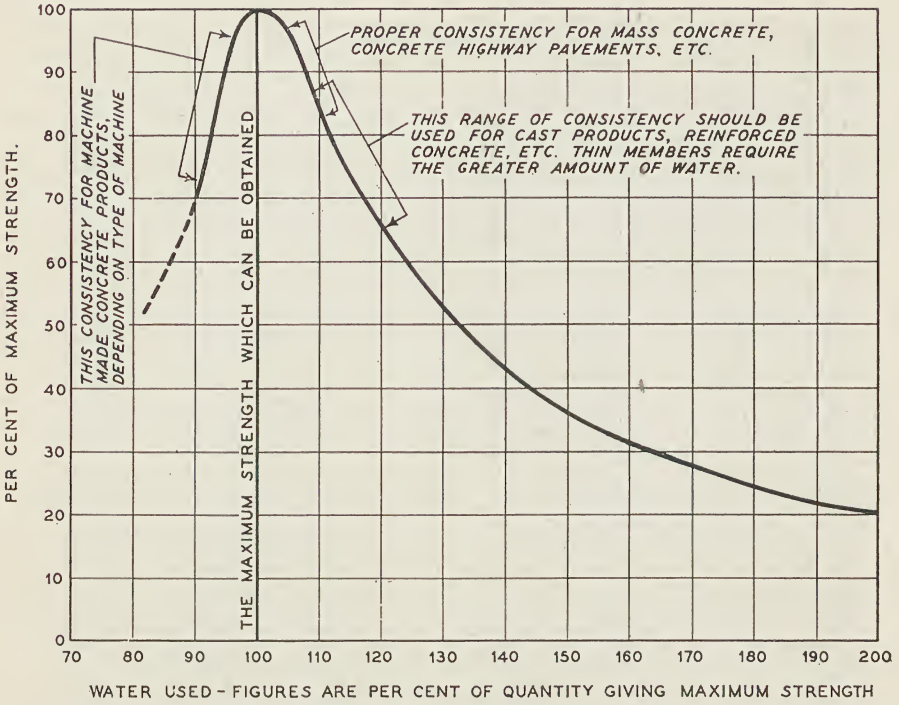


Fig. 5.—WATER CONTENT STRENGTH CURVE

Note 30 per cent. excess of water reduces the strength of the concrete to one-half.

Wherever possible, it is advisable to use fresh water from the town supply.

The quantity of water used in mixing is most important, and several factors must be taken into consideration in determining the quantity to be used. The natural tendency is to use too much. This results in a sloppy mix, which is easy to work round the steelwork but which does not give a sound concrete.

The diagram (Fig. 5) gives some idea of the effect of water content on the strength of the concrete. From this, it will be seen that the strength falls rapidly if either too little or too much water is used.

An attempt was made in America to standardise the amount of water to be used by means of a fixed cement-water ratio. The specification would allow, say, 5 gal. of water to 1 cwt. cement, and the contractor was allowed to add as much aggregate as he wished in order to give a workable mix. This method is not by any means foolproof, and has not been adopted in this country.

A more reasonable method is to allow 28 per cent. of the weight of cement plus 4 per cent. of the weight of the aggregates, making due

allowance for any water which may be contained in the sand. This gives results as follows :—

TABLE II

WATER USED FOR VARIOUS MIXES

Mix	*Weight of Materials (Lb.)*			*Volume of Materials (Cu. Ft.)*			*Water (Lb. per 112-lb. Bag of Cement)*			*Water per Bag of Cement (Gal.)*	*Water per Cu.Yd. of Sand and Ballast (Gal.)*
	Cement	*Sand*	*Ballast*	*Cement*	*Sand*	*Ballast*	*28 per cent. Cement*	*4 per cent. Sand and Ballast*	*Total*		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1 : 4 : 8	112	448	896	1¼	5	10	31	54	85	8·5	15·3
1 : 3 : 6	112	336	672	1¼	3¾	7½	31	40	71	7·1	17·1
1 : 2 : 4	112	224	448	1¼	2½	5	31	27	58	5·8	20·9
1 : 1½ : 3	112	168	336	1¼	1⅞	3¾	31	20	51	5·1	24·5
1 : 1 : 2	112	112	224	1¼	1¼	2½	31	13	44	4·4	31·6

Controlling Water Content by the Slump Test

A good practical way of controlling the water content is by means of the slump test. A truncated, cone-shaped mould is used, 12 in. high, 8 in. diameter at the base, and 4 in. diameter at the top, and provided with handles. The mould is filled with concrete in layers of 4 in. at a time, each layer being rammed thirty times with a pointed metal rod $\frac{5}{8}$ in. diameter by 12 in. long. When the mould has been filled in this manner, it is slowly raised and the slump measured, from the top of the cone to the highest point of the concrete. The test should be carried out on a firm, level base, free from vibration. A slump of 1 in. indicates a very stiff mix, with very little excess water. For beams, columns, and walls the slump should be between 2 in. and 4 in., and for watertight work, from 4 in. to 5 in. The slump should never exceed 6 in. The amount of water required to give the necessary slump should be checked over every 2 or 3 days, as the water content in the sand and aggregate may vary, and as the slump will also be affected by any variation in the grading of the materials in different delivery batches.

Mixing

Concrete may be mixed either by hand or by machine. Hand mixing is quite satisfactory, providing proper precautions are taken and

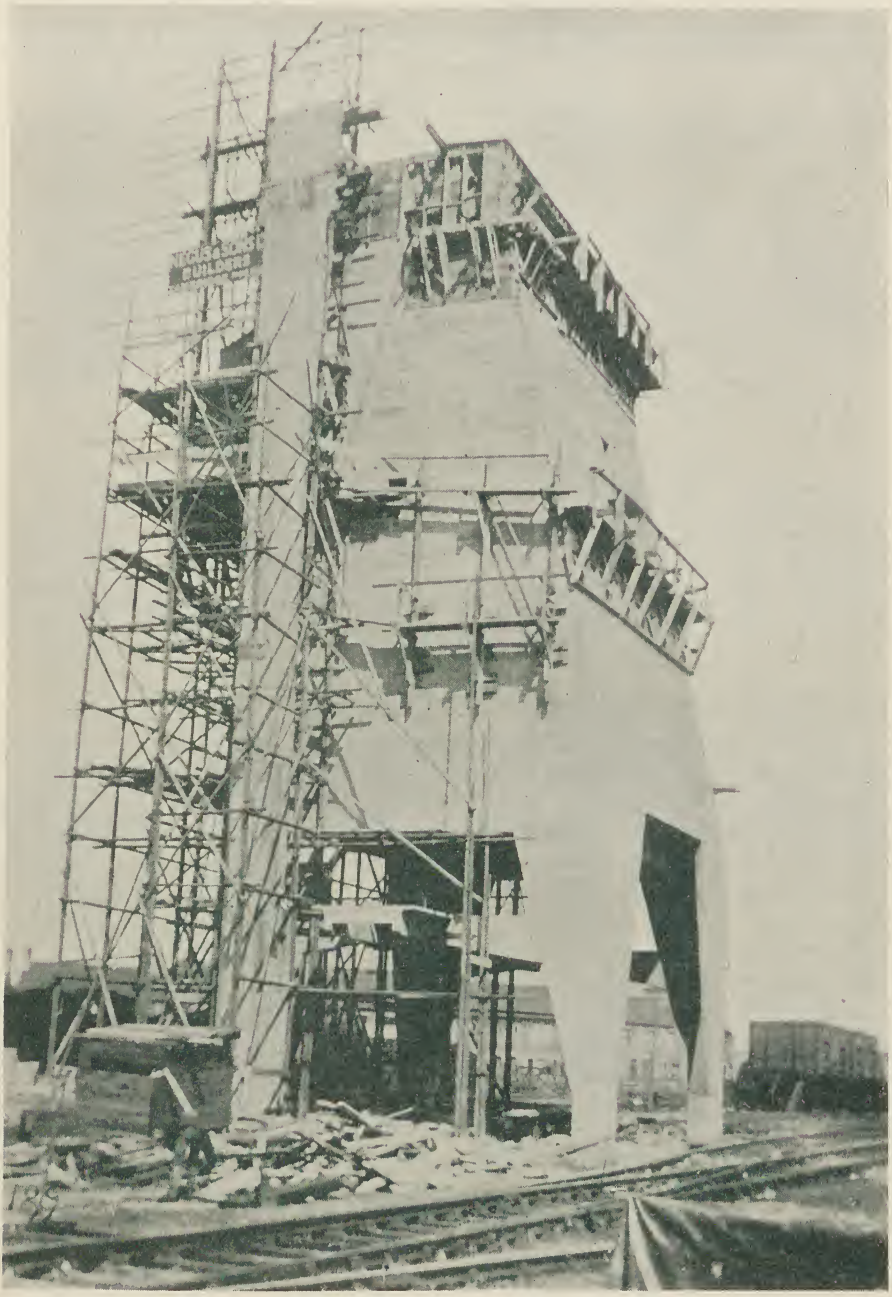


Fig. 6.—REINFORCED CONCRETE FOR COALING BUNKERS FOR L.N.E.R., CAMBRIDGE
(*Reinforced concrete engineers : John Liversedge & Co.*)

providing the men know their job, but with the increased use of mixing machines, hand mixing has almost died out, and in order to guard against careless mixing, it is usual to specify that 25 per cent. extra cement be used for hand mixing. The first essential is a good, close-jointed platform, large enough to allow the material to be turned over freely without spilling. It is a mistake to work with a small or badly constructed platform. The materials should then be measured and turned over three times dry and three times wet, water being added from the rose of a watering can. The batch should not be larger than ½ cu. yd., or further mixing will be necessary. Machine mixing reduces the human factor and gives a more reliable mix. The mixing machine should be of the batch type, and of a size suitable to the rate of progress required. It is worth while giving some thought to the layout of concreting plant in order to get the best results. The materials should always be measured, either in gauge boxes or in standard barrows, and it is an advantage to have a size of batch which requires 1- or 2-cwt. bags of cement. The materials should be mixed dry before adding the water. As previously explained, the amount of water used in mixing is most important, and should always be carefully controlled, to give the required slump and the correct quantity measured for each batch.

Using Ready-mixed Concrete

It is interesting to note, in passing, that concrete may be purchased in London ready mixed. The materials are mixed in a revolving drum on the delivery vehicle and water added as the site is approached. It is not advisable to transport fluid concrete any considerable distance, as the materials tend to segregate.

Placing and Tamping

Concrete should be placed in position as soon as possible after mixing, and always before the initial set takes place, which may be within 20 minutes, although it is usually somewhat longer and varies considerably with different batches of cement. Before commencing to place the concrete, a careful inspection should be made to see that all steel reinforcement is correctly fixed, and that the formwork is rigidly braced and strutted. All sawdust, wood, dirt, or other foreign matter must be removed, and the face of the shuttering treated with mould oil, soft soap, or any other preparation which may have been specified, although, in general, these should have been applied before the reinforcement was fixed. A check should also be made to see that all boxing or blocks for openings, bolt holes, etc., are in the correct position, as this may save considerable time and money in cutting away afterwards.

The concrete should be placed carefully in position in small quantities, and not thrown from a height or tipped in bulk. As soon as the concrete is placed, it must be well rodded into position around the reinforcing bars

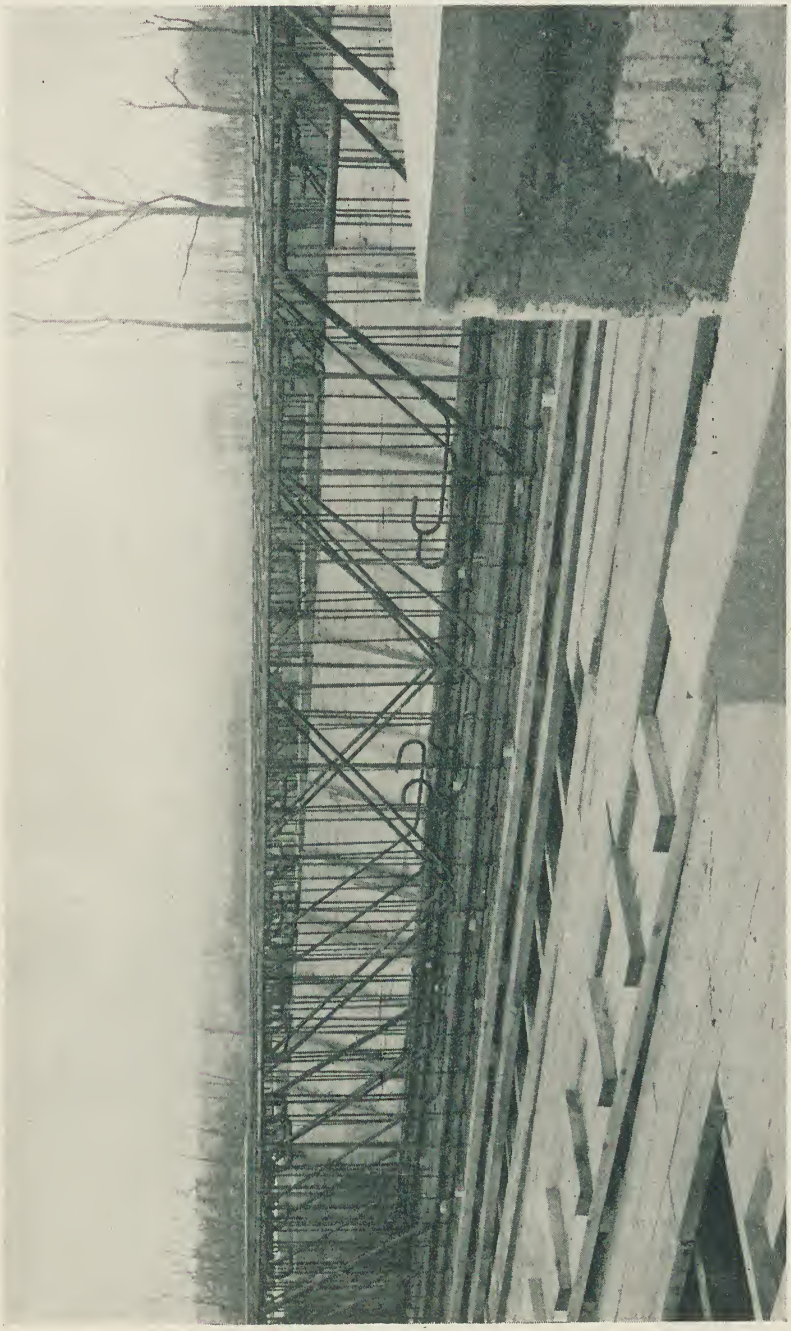


Fig. 7.—WENSUM BRIDGE, NORWICH, SHOWING THE REINFORCEMENT IN THE MAIN BEAM. (*Reinforced concrete engineers : John Liversedge & Co.*)

and along the face of the shuttering. Failure to give adequate attention to working the concrete into position will result in porous concrete with a honeycomb surface. Column heads and junctions of beams should receive special attention. Very good results are obtained by using specially designed vibrators working at a frequency of from 6,000 to 12,000 vibrations per minute. Properly applied, these result in a very dense concrete with a good working face, and the water content may often be reduced. Over-vibration should be avoided, as it tends to cause segregation of the materials.

It is not advisable to mix or place concrete during frosty weather except for urgent work, when special precautions must be taken. The sand and gravel should be heated and the work well protected. The greatest damage is done by frost just after the final set has taken place, and concrete thus frozen is completely disintegrated. Rapid-hardening and aluminous cements are of advantage in cold weather, as they generate more heat than slow-setting cements, and this helps to raise the temperature of the concrete during the hardening process.

Construction Joints

As a general rule, it is advisable to carry out concreting as continuously as possible, in order to reduce the number of construction joints to a minimum. Where construction joints are unavoidable, the positions should be carefully determined beforehand. In beams and slabs, the concrete should be stopped at a vertical face where the shear is low, either over a support or within the middle third, preferably the latter. Beams are usually concreted before the slab, and this enables the number of joints in beams to be reduced to a minimum. Horizontal joints in walls should be made straight and true to level, as uneven joints can be most unsightly. A good tip is to fix a small batten at the top of the shutter, as shown in Fig. 9.

When work has to be resumed on a surface that has hardened, every care should be taken to make a sound joint. The old surface should be well roughened and all laitance removed, after which it should be swept clean, thoroughly wetted, and covered with a layer of mortar composed of equal parts of cement and sand, well worked in. Special precautions should be taken in watertight work.

Expansion Joints

Concrete, like most other materials, expands when heated and contracts on cooling, and it is necessary to take this into consideration if temperature cracks are to be avoided. When heated through 70° F., which range of temperature is quite common in this country, a length of 100 ft. of concrete will expand about half an inch. When joints can easily be provided, as in slabs on solid ground, the concrete should be cast in bays not exceeding 50 ft. in length, and the joints filled with 1-in.

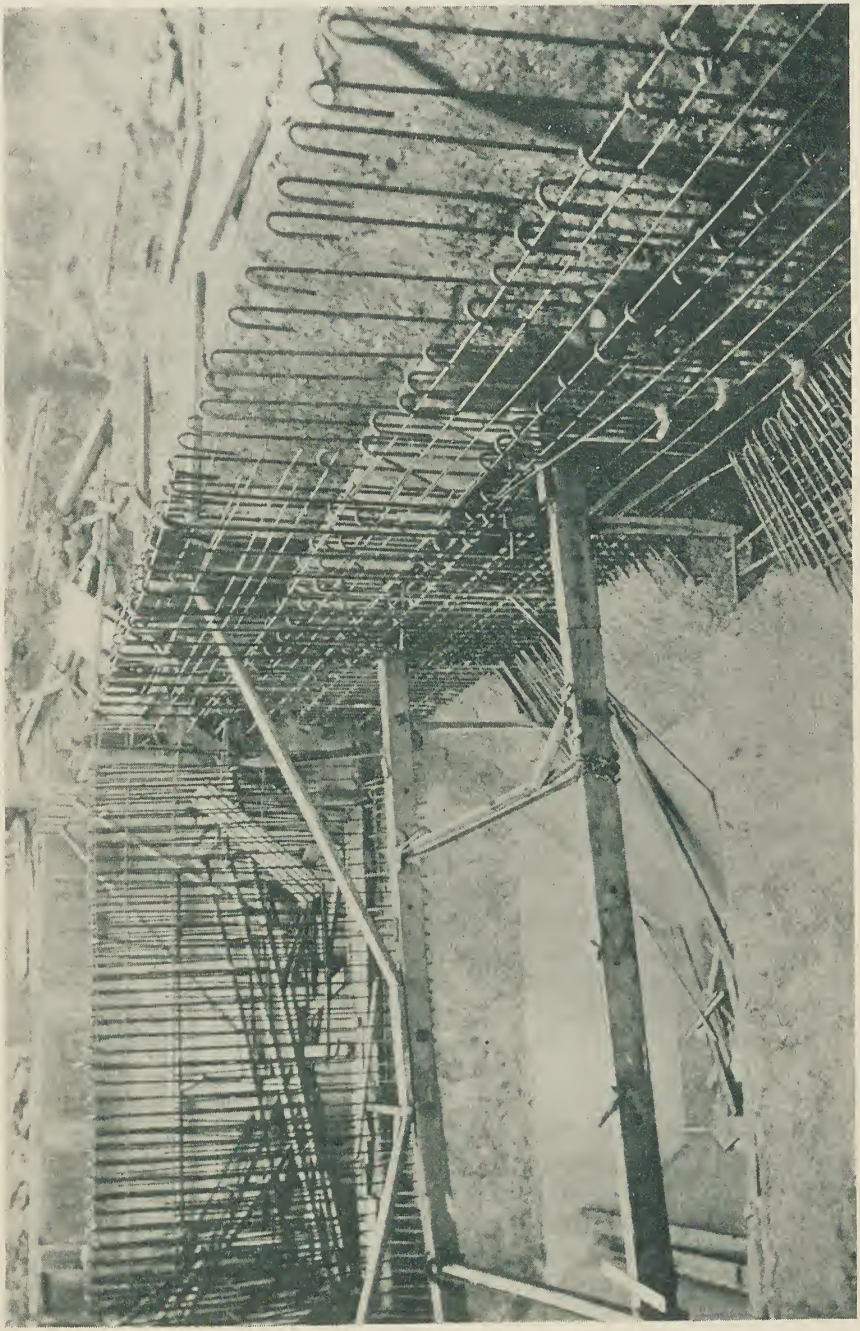


Fig. 8.—REINFORCEMENT FOR DETRITUS PITS, GLENBOIG SEWAGE WORKS. (*Reinforced concrete engineers : John Liversedge & Co.*)

thickness of bitumen or cork. In a complete reinforced-concrete structure, it is usual to allow for expansion joints about 150 ft. apart, and in composite structures, the bearing surfaces should be made as frictionless as possible to allow freedom of movement between the different materials.

Curing

Concrete cannot develop its full strength unless kept in a moist condition during the hardening process. In practice, it is advisable to keep it moist for at least 7 days, and to protect all exposed surfaces from wind or sun by covering with sand or sacking, moistened from time to time. At 28 days, concrete cured in water is about 12 per cent. stronger than concrete cured in air.

Steel Reinforcement

This usually consists of mild steel, in accordance with British standard specification No. 15, which specifies a breaking strength of from 28 to 33 tons per square inch. In addition, there are various special bars and fabrics on the market. All steel reinforcement should be carefully checked over upon arrival at the site, and stored for easy access. The steel should be clean when placed in the work, free from mill scale, loose rust, oil or grease, or other deleterious matter. Care should be taken to see that the bars are bent accurately to shape, or otherwise difficulty will be experienced in fixing. Steel-bending may be done either at the works or on the site, but, in either case, the bars should be bent cold in a suitable bending machine. As soon as bent, the steel should be labelled for easy reference when fixing. It is, of course, most important that the steel reinforcement be accurately and rigidly fixed in position, the bars being wired together with soft-annealed binding wire, and the whole of the steel should be checked over in position before concreting commences.

Shuttering and Formwork

The construction and erection of formwork comprises a large percentage of the cost of reinforced concrete, usually between 25 per cent. and 40 per cent., and it is often worth while preparing special designs and drawings for the use of the foreman on the site, especially in large and complicated works. For ordinary beam and slab construction, the shuttering may be safely left to an experienced foreman. It is advisable to have all timbering of substantial size, and all formwork should be well strutted and braced so as to prevent any excessive deflection when carrying the dead weight of the concrete. It is false economy to use thin sheeting, which may bulge under the pressure of the concrete : such mistakes are expensive to rectify. To prevent loss of grout, all joints must be tight and, as a general rule, wrought timber should be used for all

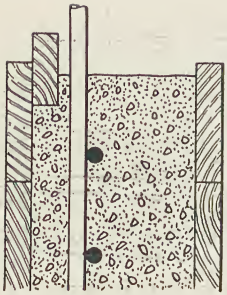


Fig. 9.—A SMALL BATTEN FIXED AT TOP OF SHUTTER ENSURES A STRAIGHT JOINT

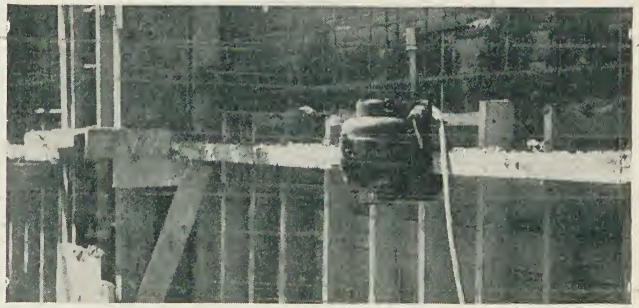


Fig. 10.—AN ELECTRIC VIBRATOR. (*By courtesy of E. P. Allam & Co. Ltd.*)

exposed surfaces of concrete. As previously mentioned, the shuttering should be cleaned and treated with soft soap or mould oil before concreting commences.

Shuttering should be left in position as long as possible. The minimum time which should be allowed between the placing of the concrete and the striking of the forms depends upon the position in the structure, the climatic conditions, and the quality and setting-time of the cement. The minimum intervals for work done in normal weather, with a temperature of round about 60° F., will be as follows :—

	Normal P.C. Concrete	*Rapid-hardening P.C. Concrete*
Beam Sides, Walls, and Columns . .	3 days	2 days
Slabs (props left under) . . .	4 ,,	3 ,,
Remove props (to slabs and beams; soffit props left under)	10 ,,	5 ,,
Remove props to beams . . .	21 ,,	10 ,,

All props must be eased slowly, and care must always be taken when striking the shuttering, so as not to jar the concrete unduly. For concrete mixed with aluminous cement, the whole of the supports can be removed after 40 hours, and with beam sides, walls, and columns, after 12 hours.

Test Cubes

It is always advisable to keep a check on the quality of the concrete by means of test cubes. These should be cast in steel moulds with a 6-in. side, which should be filled with concrete from an actual batch and, as far as possible, the conditions of curing should be similar to those in the actual job. These test pieces will have to be sent to a testing laboratory for crushing at 7 days, 28 days, and 3 months. The 28-day test is, perhaps, the most valuable, as it is usual to allow this period of time before putting any considerable load on the structure. The results of these tests should give a strength at 28 days of at least four times the working strength when ordinary Portland cement is used.

ASPHALTE IN MODERN BUILDING PRACTICE

Fig. 1.—A PRIVATE INDOOR SWIMMING BATH LINED WITH THREE COATS OF NATURAL ASPHALTE ROCK MASTIC

The photograph shows the reinforced-concrete loading coat in process of being applied.

ASPHALTING is one of the recognised sub-contracting trades in the building industry, and has its own section in the *Standard Method of Measurement of Building Works.* It will also appear as a separate item in a *British Standard Specification for Sequence of Trade Headings and Specification Items.*

There are, however, at present, no B.S.I. specifications for the composition of asphalte for various building purposes. Those which have been published are applicable only to road work, and cannot be taken as a guide to building practice.

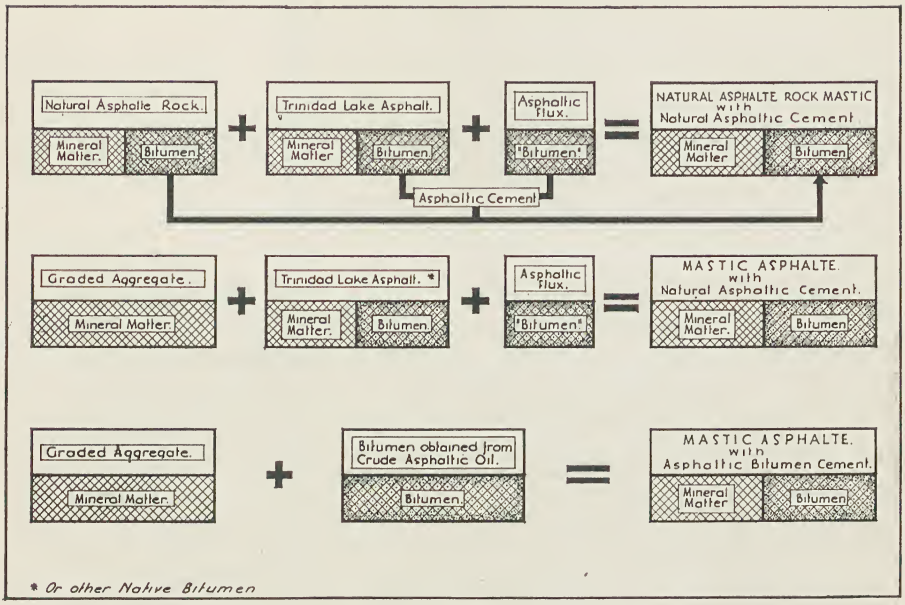


Fig. 2.—TYPES OF MASTIC ASPHALTE

Type of Asphalte Used in Building

Asphalte is a natural or mechanical mixture, in which asphaltic bitumen is associated with inert mineral matter, and this definition covers a wide range of possible materials.

It is therefore essential for the architect and the builder to understand something of the various ways in which asphalte can be made for use as a roof covering, for damp-coursing, for tanking basements, or for flooring, and types of mixtures are illustrated in Fig. 2.

The kind of asphalte used in building is known as mastic asphalte, and differs from other types in that it is a mixture of natural asphalte rock (and/or other aggregate) and asphaltic bitumen, in such proportions as to give a plastic and practically voidless mass which can be laid by hand while in a hot, fluid condition.

It differs from the mastic asphalte sometimes used for road surfacing, principally in regard to the proportion and properties of its bituminous components, and also to the fact that for building work the average size of the particles of aggregate is considerably smaller.

Composition

When first introduced into this country nearly a century ago, the aggregate consisted entirely of natural bituminous limestone imported from Europe, to which enough bitumen was added to make a mastic.

A certain proportion of fine grit was also incorporated. It was on the basis of the excellent results given by material manufactured in that way, that the industry progressed.

While improvements have been introduced since then, and technical knowledge has advanced, informed opinion to-day is definite that, particularly for roofing purposes, a substantial proportion of naturally occurring asphalte is essential for the production of a first-class material with a long life.

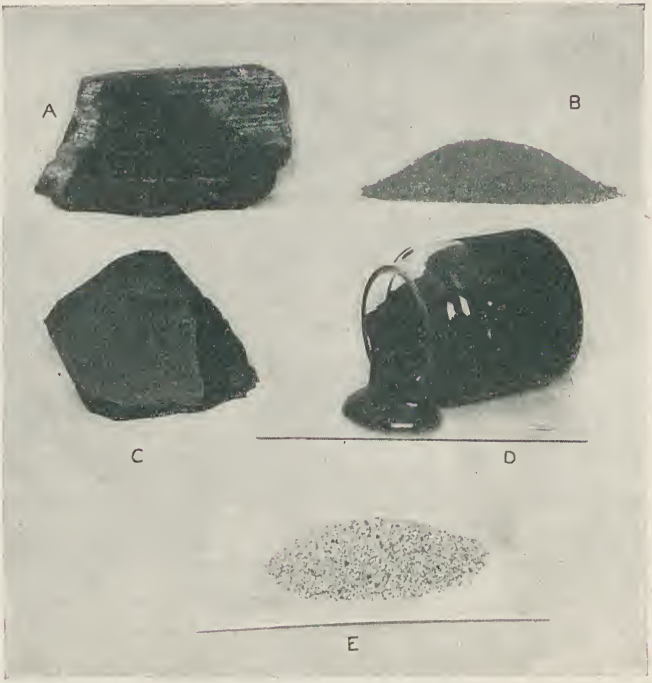


Fig. 3.—THE RAW MATERIALS OF NATURAL ASPHALTE ROCK MASTIC

A, the rock as mined. B, the rock after crushing. C, the refined Lake asphalt. D, the asphaltic flux. E, the siliceous grit.

In support of this, the reader is referred to various pronouncements of the Building Research Board in their annual reports and answers to questions.

In the early days of the industry, substitutes appeared which were much cheaper, some of which were based on the use of coal-tar pitch, which it should be understood is substantially different from asphaltic bitumen in chemical and physical properties. The use of coal-tar pitch in building asphalte intended as a waterproof covering is practically certain to be attended by failure. During the last twenty years or so, others have been made based on various manufactured bitumens which have come on to the market, which cannot properly be described as naturally occurring products. These, owing to their lower cost, have been used considerably, but unfortunately not always with satisfactory results.

To quote from two annual reports of the Building Research Board :

" Experience has shown that old roofs, constructed from natural products, have weathered well. . . . There is a general consensus of

(1) ROOF COVERING .	On roofs of concrete, timber, or other form of construction :— Including : those subject to traffic, e.g. sun decks, roof gardens, playgrounds. Embodying : skirtings, lining gutters, and outlets, covering cornices and dormer faces.
(2) DAMP-PROOFING .	Ordinary damp-courses : horizontal and vertical. In buildings : above or below ground level. In engineering : e.g. railway works.
(3) WATERPROOFING .	" Tanking " foundations below ground level (usually subject to water pressure) :— Applied in three coats. Protected by concrete or brickwork.
(4) INTERNAL LININGS	Reservoirs, water towers, tanks for hot or cold water. In connection with industrial processes :— Tanks containing non-corrosive or corrosive liquids at normal or high temperatures. Low-temperature work, e.g. brine-storage tanks in cold-storage chambers. Usually all three-coat work.
(5) PAVING . .	Footways, courtyards, areas, platforms, wharves, ships' decks. Balconies, terraces, trafficked roof decks.
(6) FLOORING . .	In industrial buildings subject to light, medium, heavy, or special forms of traffic (particularly where processes demand absence of dust) :— Acid-resisting : various grades ; for use at normal or high temperatures. As an underlay for other finishes, e.g. linoleum, cork, and rubber. Coloured : various types of decorative finish. Special forms, e.g. :— Reinforced with steel mesh for heavy duty. Gritless—as a flooring in explosive factories.
(7) OTHER USES .	Expansion joints ; jointing concrete and metal pipes. In connection with certain forms of electrical work. Road surfacing.

Fig. 4.—PRINCIPAL CLASSES OF MASTIC ASPHALTE WORK

opinion that the adulteration of natural rock asphalts with synthetic materials is, at any rate in part, a cause of the failures which are reported from time to time. . . ."

Reasons Underlying the Use of Asphalte

Good-quality asphalte has a combination of advantages to recommend its use. From the dawn of history it has been realised that asphaltic

Fig. 5.—ASPHALTING OPERATIONS

In this illustration the workman on the right is laying the top (second) coat of asphalte over a section of a flat concrete roof. The correct thickness of asphalte is obtained by laying to wooden gauges, which are removed as each section is completed. The bottom coat has been partly laid, and can be seen projecting beyond the edge of the top coat into the adjoining bay, thus ensuring a broken " joint " between the two layers.

The workman on the left is rubbing fine sand into the freshly laid top coat. This is partly to neutralise any excess of bitumen which may occur in the surface in the form of a very thin skin, but the sand also acts as a kind of lubricant in giving the asphalte a smooth finish. The board on the right is known as a " straight-edge," and is used for testing the evenness of the finished surface.

bitumen is an ideal medium with which to protect porous materials from water. Both brickwork and concrete, as ordinarily used in modern buildings, are either pervious to water or liable to become so, and even if virtually impervious, they may at any time subsequently develop cracks or paths, which may allow moisture to penetrate. If protection is sought by means of materials applied in the form of strips or sheets, apart from other factors, and irrespective of their composition, every joint in these is a potential line of weakness.

Mastic asphalte, on the other hand, after proper application has no joints, and is entirely monolithic and homogeneous. While it is applied in sections " or bays," in the first place, owing to its properties, each area " marries " to, or " welds " perfectly with, adjacent ones. Also (except sometimes in the case of flooring) asphalte is applied in more than one coat, and the edges of the sections of the top coat are made to overlap those underneath, so that no two are coincident.

Fig. 6.—LINING THE INTERIOR OF A WATER TOWER WITH NATURAL ASPHALTE MASTIC

After application in the hot, fluid condition, owing to its plastic nature, it does not develop shrinkage cracks on cooling. The reduction in volume which occurs takes place by a very slight uniform diminution in the original thickness. Neither does it pass through a period of setting comparable with concrete, and is not therefore susceptible to the formation of cracks on that account. It forms an independent, impervious, plastic covering over materials which possess certain shortcomings inherent in their rigid nature and chemical structure, and which may be liable to the formation of fissures due to settlement, thermal and moisture movements, and initial drying shrinkage.

Integral waterproofers for concrete do not purport to assist in preventing crack formation, and hence can only waterproof that portion of the concrete which is uncracked.

Asphalte is now generally laid on a thin membrane which is not affixed to the concrete, and is therefore isolated from it, and in consequence if cracks do form in the concrete they should not be correspondingly transmitted to the asphalte. Moreover, its plastic nature allows it to accommodate itself, within reasonable limits, to movements in the foundation. The underlay also obviates the formation of blisters which, under certain conditions, may otherwise develop in the asphalte when laid on concrete. Asphalte itself does not give off gases at ordinary temperatures, and does not react chemically with concrete.

Manufacture

The raw materials of which natural asphalte rock mastics are composed are shown in Fig. 3. The best rocks consist of practically pure limestone which, in past geological time, has become substantially impregnated with

asphaltic bitumen (a compound having an origin cognate to petroleum). The lake asphalt contains a high proportion of native bitumen, associated with finely divided mineral matter.

No naturally occurring asphaltic materials are found in this country in commercial quantities. The asphalte rock has therefore to be imported from mines in Europe, and the lake asphalt from Trinidad.

The process of manufacture is one of mixing only, and is not dependent on chemical reactions. When all the ingredients have been thoroughly amalgamated, the bitumen in the rock and the lake asphalt, together with the flux (if any), form a homogeneous cement in which the impregnated particles of rock are uniformly dispersed. The rock particles, on analysis, often yield some 60 per cent. of very fine limestone powder, passing a sieve with apertures of ·003 in. and smaller.

Fig. 7.—APPLYING A VERTICAL ASPHALTE DAMP-COURSE

The siliceous grit is often obtained from natural beach deposits, and should comply with a certain grading. It should be incorporated in the asphalte at the time of manufacture, and not on the site of the work. The process of manufacture calls for skilled direction and technical control, and firms of repute are equipped with laboratories under the supervision of qualified chemists. Both the raw materials and the finished product are submitted to tests by means of special forms of apparatus, some of which must be very accurately constructed and are very sensitive.

Fig. 8.—APPLYING AN ASPHALTE SKIRTING OVER A DWARF BRICK WALL AT THE BACK OF A CONCRETE VALLEY GUTTER

An example of work being carried out in a confined space.

Application

One of the advantages of asphalte is its adaptability. It can be applied continuously over vertical and sloping surfaces, around projections and in recesses, and at the base of upstands, without any break in its continuity, and is much more convenient than any form of sheet application, which must be jointed, particularly where finishes are necessary in places not easy of access.

The principal classes of asphalte work are set out in Fig. 4 and, as will be seen, are numerous and varied. Drawings showing examples of forms of construction where it is employed in basements and on roofs, will be found in Data Sheets 5 and 6 issued as supplements to this work. Others are published by the Natural Asphalte Mine-Owners & Manufacturers Council. The illustrations on these pages show examples of work in progress.

Although the principal manufacturing process is carried out in factories before the asphalte arrives on the site, it cannot be laid until it has been remelted, and a great deal of harm can be done if this is not carefully superintended. The best asphalte can be ruined by overheating. Much of the "goodness," i.e. the constituents which give the asphalte pliability and waterproofness, are driven off and undergo chemical change. This has doubtless been the cause of certain failures which have occurred. Not only must the material as a whole be brought, gradually, to the correct temperature, but it is also important to avoid local overheating. If this occurs, particles of burnt material may find their way into the laid asphalte and possibly impair its impermeability.

Adequate and constant stirring of the mixture is necessary on this account alone, but it is particularly so when it contains grit or granite chippings. If the mass is not continually kept in motion, the heavier

Fig. 9.—ACID-RESISTING FLOORING ASPHALTE BEING LAID IN THE PRINTING AND DEVELOPMENT ROOM AT THE PREMISES OF ONE OF THE LONDON DAILY NEWSPAPERS

constituents tend to sink to the bottom, and in consequence the asphalte is not uniform in composition and properties.

These considerations and other technicalities of manipulation can only to a limited extent be defined, and the experience of the asphalte layer and his potmen must be relied upon to know when the material is " just right " for application. It takes a good many years to qualify as a spreader and, as in other skilled trades, an apprenticeship or other period of training has to be served.

Construction and Design of Buildings

It should be borne in mind that the qualities of asphalte can only be used to the best advantage if the construction of the parts of the building to which it is applied has been well designed. Asphalte, being of a plastic nature, must be laid on foundations of adequate strength, and in cases where pressure of water exists, it must be protected by loading coats. In many cases where failure has occurred, the greater part of the trouble can be attributed to unsatisfactory construction.

Recent developments in the design of buildings make it necessary to reconsider certain traditional methods of construction, and in this connection the reader is referred to an article, in the *Journal of the Royal Institute of British Architects*, on " Flat Roofs " (7th Nov. 1936), emanating from the Building Research Station.

Fig. 10.—A TYPICAL ASPHALTE-TESTING LABORATORY

Asphalte Floors

Asphalte is extensively used for :—

(1) The flooring of factories, breweries, etc.

(2) The flooring of dairies, the lining of whey tanks, and other processes in dairying.

(3) Decorative work in the flooring of housing schemes, public institutions, etc.

(4) The flooring of explosive houses and magazines, with special reference to situations where absence of friction and the inability to form explosive salts are essential.

(5) The lining and flooring of brine pits in connection with refrigeration plant and cold-storage work generally.

This list is of necessity but a brief indication of the varied uses to which asphalte is now put, and many other instances, such as railway platforms, goods depots, etc., will occur to the mind of the reader.

For Floors subject to Heavy Wear

Heavily gritted forms of asphalte will withstand extremely onerous traffic conditions without deformation or appreciable wear, chiefly due to the fact that they will resist fracture from traffic impact and have no visible joints to work loose—both frequent causes of disintegration in rigid floors. In certain circumstances, however, asphalte will tend to mark under heavy standing loads or by the constant movement of loads

with little or no distribution of weight, such as milk churns (in rolling position), etc. In order to overcome this difficulty, a method is adopted whereby a continuous mat of steel mesh is built up, into which the asphalte is poured. The mesh prevents the asphalte from " pushing " and at the same time reinforces it, the steel itself becoming part of the wearing surface. This method can also be used purely as a local reinforcement should heavy traffic be encountered only on certain places on the floor.

Perhaps one of the main advantages of asphalte as a flooring proposition is that it can be laid upon old floors and does not of necessity require a concrete foundation. Thus, in the reconditioning of buildings, the floors, however uneven and whether of timber, brick, concrete, or stone, present a good base for the asphalte covering without further treatment. The asphalte takes up all irregularities, and the finished floor presents a smooth, resilient, and dustless surface.

Coloured Asphalte Floors

Asphalte has been considerably popularised during recent years by its introduction in colour. This has encouraged its use for many domestic purposes which hitherto it was unable to fulfil owing to its original lack of attractiveness in appearance. The first real demands for the use of coloured asphalte were instigated by the call for a sanitary, vermin-proof flooring in existing housing schemes, many of which had been condemned because of the wholesale cracking and subsequent insanitary disintegration of the floors. Asphalte, owing to its bituminous cementing agent and consequent degree of resilience, will withstand sudden stresses due to rapid temperature changes, and will resist impact forces without cracking, far better than many more-rigid types of surfacing. With this advantage, a wide field of decorative use has been opened for coloured asphalte, and it is now used for hospitals, canteens, public-houses, cafés, entrance halls, dressing-rooms, etc., and, in fact, all types of floors where colour combined with hard wear is required. Red is the most popular and economical shade, but green, brown, and grey asphalte can also be supplied, the colour being in each case permanent and incorporated evenly throughout the mixture. Attractive variations to ordinary, plain-coloured asphaltes can be obtained by the incorporation during manufacture of coloured marble chippings. In order to bring these to view, the floor is polished with automatic carborundum grinders after it has been laid. The resulting surface resembles a terrazzo finish and gives an attractive, non-skid surface free from cracks.

Asphalte as an Underlay

Asphalte as a flooring material does not always act as the wearing surface, but sometimes occupies a position as a damp-proof underlay to rubber or linoleum. Considerable areas are laid for this purpose, about $\frac{1}{2}$ in. thick, but those specifying asphalte in this connection are urged to

Fig. 11.—ASPHALTE FLOORING AT OLYMPIA

Fig. 12.—ASPHALTE ON G.W.R. PLATFORM

ensure that the contractor is offering to lay a suitably hard grade and has experience in this class of work.

Acid-resisting Asphalte

This is yet another grade of asphalte which has made rapid strides in recent years. Work with acid-resisting asphalte is carried out in both tanking and flooring in connection with printing-works, jam and pickling factories, breweries, precious-metal refining processes, etc., and a host of other commercial undertakings. Especial care must be observed in the manufacture of the various grades used ; for tanking work, the asphalte must withstand the constant action of the liquor for long periods of service without breaking down ; whilst floors must also be hard enough to stand up to the stresses imposed by high temperatures and heavy traffic. It is difficult to lay down a hard and fast rule as to what acids and concentrations of liquors asphalte will withstand, as temperature and other circumstances have to be taken into consideration. A rough guide, however, can be gained from the following list.

A series of specifications is available that can be employed for :—

(1) Inorganic acids up to high concentration and/or temperature.
(2) Alkalies, solid and liquid.
(3) A limited range of organic acids.
(4) Sugars.
(5) Brewing liquors, cider, etc.
(6) Complex liquors as are met with in precious-metal refining and chemical processes.
(7) Milk and certain associated substances.

Asphalte in Refrigerated Spaces

Very large areas of asphalte have been laid as flooring to cold stores. It is waterproof, and possesses reasonable thermal properties, thus protecting the insulation below and ensuring a constant and easily controlled temperature. The material can be used as a wearing surface without detriment to its efficiency, and will withstand heavy loads and varying temperatures without danger of cracking and subsequent failure of the insulation. It can also be applied vertically to walls and, if necessary, on the ceilings of a chamber.

Specification

In conclusion, it cannot be over-emphasised that in view of the various ways in which material can be made and described as " asphalte," every care should be taken to ensure that competitive tenders are on a comparable basis, in other words, that the contractors are in fact quoting for the same class of material. Those manufactured with good-quality, naturally occurring asphalte cannot be as cheap as those not so made, and to accept a quotation on price alone, without inquiry as to the composition of the material offered, may be to court subsequent failure.

QUESTIONS AND ANSWERS

What type of Asphalte is used in building ?

Mastic asphalte, a mixture of natural asphalte rock (and/or other aggregate) and asphaltic bitumen, in such proportions as to give a plastic mass which can be laid by hand in a hot, fluid condition.

How does Mastic Asphalte differ from the Mastic Asphalte sometimes used in Road Surfacing ?

Principally in regard to the proportion and properties of its bituminous components. For building work the average size of the particles of aggregate is considerably smaller.

What are the Advantages underlying the use of Mastic Asphalte ?

(1) Impervious to moisture.
(2) Can be applied without joints through which water could enter.
(3) Does not develop cracks.
(4) Owing to its plastic nature it can accommodate itself, within reasonable limits, to movements in the foundation.

How are Cracks developing in the Concrete Foundation prevented from being transmitted to the Asphalte ?

The asphalte can be laid on a thin underlay which is not affixed to the concrete.

What happens if the Asphalte is Overheated ?

The constituents which give the asphalte pliability and waterproofness are driven off and undergo chemical change.

What precautions must be adopted when remelting Asphalte on the site ?

(1) It must be brought gradually to the correct temperature.
(2) Local overheating must be avoided by constant stirring of the mixture.

How is Asphalte Flooring reinforced for very heavy duties ?

By means of a continuous mat of steel mesh into which the asphalte is poured.

USEFUL TABLES ON COPPER PIPES

THE frictional resistance offered by copper tubes to the flow of water is given in the Table below, which shows the result of actual tests, by the Copper Development Association, on pipe employing water velocities up to 10 ft. per second. The flow of water in these pipes may be represented by the formula :—

$$\text{Loss of head by friction per 100 ft. of pipe} = \frac{K}{d} \times v^{n}$$

where the loss of head is expressed as feet of water pressure, d is the bore of the pipe in inches, v is the velocity in feet per second of water in the pipe, and K is the coefficient of friction.

From the results of many hundreds of actual experiments, the value of K is found to be 1·06 for iron and 0·86 for copper. n is found to be very constant for all the pipes, both copper and iron, and equals 1·8.

The same experiment has been made with lead pipe. The pipe was new and as straight as it was possible to get it. The same index for the velocity, namely 1·8, was found to hold good here also, but the frictional

FRICTIONAL RESISTANCE IN COPPER AND IRON PIPES

Frictional loss in feet head of water for each 100-ft. length of pipe carrying water at the stated rate in gallons per minute. Loss of head in copper pipes given in heavy figures. Loss of head in iron pipes given in light figures

Gallons per Minute	Sizes of Pipes. Internal Diameters								
	⅜ in.	½ in.	¾ in.	1 in.	1½ in.	2 in.	2½ in.	3 in.	4 in.
0·5	**6·23** 7·70	**1·66** 2·05							
0·75	**12·9** 15·9	**3·44** 4·24							
1·0	**21·3** 26·3	**5·92** 7·30							
1·5	**44·9** 55·5	**11·97** 14·8							
2·0	**75·5** 93·2	**20·0** 24·7	**3·11** 3·84						
3·0			**6·48** 8·0						
4·0			**10·85** 13·4						
5·0			**16·22** 20·0	**4·52** 5·57					
8·0			**37·9** 46·8	**10·05** 12·4					
10·0				**15·0** 18·5	**2·33** 2·88				
20·0				**52·4** 64·7	**8·12** 10·02	**2·14** 2·64			
30·0					**16·85** 20·8	**4·45** 5·49			
40·0					**28·3** 34·9	**7·46** 9·20	**2·67** 3·17		
60·0						**15·5** 19·1	**5·55** 6·85		
80·0						**26·0** 32·1	**9·32** 11·5		
100·0							**13·9** 17·2	**6·06** 7·48	
150·0								**12·58** 15·5	**3·36** 4·15
200·0								**21·1** 26·0	**5·6** 6·82
300·0									**11·7** 14·4

(*Copper Development Association*)

coefficient K is 0·94, showing that lead comes almost half-way between copper and iron.

These figures are for new, clean pipe. The disparity between copper and iron will increase very rapidly in use, because (1) the iron in rusting occupies a greater volume and therefore decreases the water space, and (2) the rusting iron will be rougher and therefore have an increased coefficient of friction.

WEIGHT OF COPPER TUBES

Pounds per Foot (Tubes expressed by size of bore)

Thickness of Wall S.W.G. Inches	20 ·036	19 ·040	18 ·048	17 ·056	16 ·064	15 ·072	14 ·080	13 ·092	12 ·104	11 ·116	10 ·128	9 ·144	8 ·160	7 ·176	6 ·192	5 ·212	4 ·232
Bore of Tube																	
⅛ in.	·07	·08	·10	·12	·15	·17	·20										
¼ in.	·12	·14	·17	·21	·24	·28	·32	·38									
⅜ in.	·18	·20	·25	·29	·34	·39	·44	·52									
½ in.	·23	·26	·32	·38	·44	·50	·56	·66	·76								
⅝ in.	·29	·32	·39	·46	·53	·61	·68	·80	·92	1·04							
¾ in.	·34	·38	·46	·55	·63	·72	·80	·94	1·07	1·21							
⅞ in.	·40	·44	·54	·63	·73	·82	·92	1·08	1·23	1·39							
1 in.	·45	**·50**	·61	·71	·82	·93	1·04	1·21	1·39	1·57	1·75						
1¼ in.		·62	**·75**	·88	1·02	1·15	1·29	1·49	1·70	1·92	2·13	2·43					
1½ in.		·74	**·90**	1·05	1·21	1·37	1·53	1·77	2·02	2·27	2·52	2·86					
1¾ in.			1·04	1·22	1·40	1·59	1·77	2·05	2·33	2·62	2·91	3·30					
2 in.			1·19	1·39	1·60	1·80	2·01	2·33	2·65	2·97	3·29	3·73					
2½ in.				1·73	1·98	2·24	2·50	2·88	3·28	3·67	4·07	4·61	5·15	5·70			
3 in.					2·37	2·68	2·98	3·44	3·90	4·37	4·84	5·48	6·12	6·76	7·40		
4 in.					3·15	3·55	3·95	4·55	5·16	5·78	6·39	7·22	8·05	8·89	9·74	10·80	11·88

(Copper Development Association)

Weight in pounds of 1 in. of copper pipe = the thickness of one wall × (bore of tube plus thickness of one wall); all the dimensions being expressed in inches and decimals of an inch, and the result coming in pounds and decimals of a pound.

For brass, ·96 of this weight.

The heavy figures in this and the following Table show gauges considered safe by tube makers for light copper tubes.

WEIGHT OF COPPER TUBES

Pounds per Foot (Tubes expressed by outside diameter)

Thickness of Wall S.W.G. Inches	20 ·036	19 ·040	18 ·048	17 ·056	16 ·064	15 ·072	14 ·080	13 ·092	12 ·104	11 ·116	10 ·128	9 ·144	8 ·160	7 ·176	6 ·192	5 ·212	4 ·232
Outside Diameter of Tube																	
⅛ in.	·038	·041	·044	·046													
¼ in.	**·09**	·10	·11	·13	·14	·16	·17	·18									
⅜ in.	**·15**	·16	·19	·21	·24	·27	·29	·32									
½ in.	**·20**	·22	·26	·30	·34	·38	·41	·46	·50								
⅝ in.	·26	**·28**	·33	·38	·43	·49	·53	·60	·66	·71							
¾ in.	·31	**·34**	·40	·47	·53	·60	·65	·74	·81	·88							
⅞ in.	·37	**·40**	·48	·55	·63	·70	·77	·88	·97	1·06							
1 in.	·42	**·46**	·55	·63	·72	·81	·89	1·01	1·13	1·24	1·35						
1¼ in.		·58	**·69**	·80	·92	1·03	1·14	1·29	1·44	1·59	1·73	1·93					
1½ in.		·70	·84	·97	1·11	1·25	1·38	1·57	1·76	1·94	2·12	2·36					
1¾ in.			·98	**1·14**	1·30	1·47	1·62	1·85	2·07	2·29	2·51	2·80					
2 in.			1·13	**1·31**	1·50	1·68	1·86	2·13	2·39	2·64	2·89	3·23					
2½ in.				1·65	1·88	2·12	2·35	2·68	3·02	3·34	3·67	4·11	4·53	4·95			
3 in.					2·27	2·56	2·83	3·24	3·64	4·04	4·44	4·98	5·50	6·01	6·51		
4 in.					3·05	3·43	3·80	4·35	4·90	5·45	5·99	6·72	7·43	8·14	8·85	9·71	10·58

(Copper Development Association)

PITCHED-ROOF COVERINGS

PART I.—SLATES

THE most important of the materials used by the slater and tiler for the covering of pitched roofs are shown in Fig. 1.

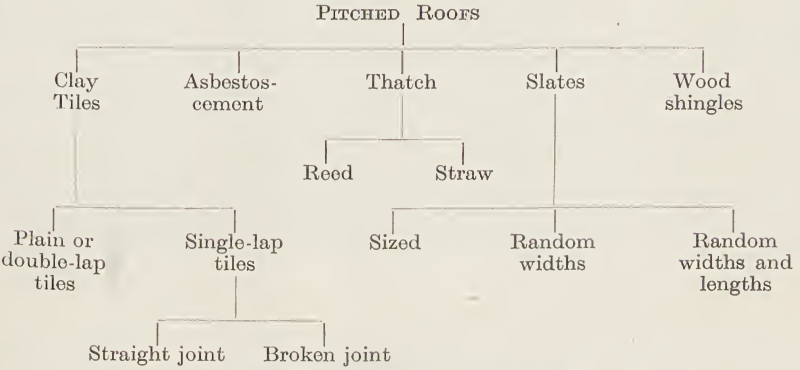


Fig. 1.—Pitched-roof coverings

In most parts of the country, slates, clay tiles, and concrete tiles are widely used in domestic work ; asbestos-cement is employed in most of the English counties, largely on factory and other industrial buildings, but to some extent also as a covering for houses and bungalows.

It is now only partly true to say that the popularity or otherwise of any particular material for roofing is dependent upon the distance from the source of supply, for modern transport facilities are such that any roofing material can be quickly carried over long distances at reasonable cost. Local prejudices and traditions do, however, still have their effect, and the other elevational materials available in a county still largely decide the kind of roofing material. Cornwall, for example, contains little or no clay that is suitable for brick and tile making : hence bricks and tiles are hardly ever used in the county. Elevations are in stone or its modern cheaper substitute—concrete, and roofs are of slate, usually Cornish, or asbestos-cement.

Welsh slates and the clay tile have been for many centuries the traditional English roofing materials, and it is of interest to note the close natural relationship of each to the other. Both are of clay, which consists of the fine particles produced by the wearing away of the primary

Photochrom Co. Ltd.

Fig. 2.—PENRHYN QUARRY—SPLITTING AND DRESSING SLATES BY HAND

rocks of the earth's surface : this wearing away was done some millions of years ago by rivers, and the particles were deposited as a sediment at the bottom of the ocean.

Origin of Slate

Slate has been formed from the earliest of these clay deposits, which were subjected to enormous pressure from the layers above, and to the internal heat of the earth, both of which contributed to a great increase in hardness. Violent earth movements that later took place, and removed parts of the lower strata from the bottom of the ocean, threw them up to form new land surfaces, and so we now have slate beds at, or near, the surface in many parts of the world. Besides displacing the hardened clays, these earth convulsions, and the great heat that accompanied them, changed the constitution of the clays, and they were re-formed as slate, giving to it the characteristic known as " cleavage " : that is, while making the material stronger and more durable than the hardened clay, they created a line of least resistance along which the slate can be easily split.

Generally speaking, the lower the original formation the greater the pressure and heat to which the clay was subjected, and the better and more durable the slate. Many Welsh slates of the oldest formations can easily be split by an expert down to one-sixth of an inch for roofing purposes.

The relationship of slates to tiles can now be stated. Slate was formed in the very earliest periods of geological time, known to geologists as the Lower and Upper Cambrian, the Ordovician, the Silurian, and (a few) the Devonian periods. The clay deposits of the Carboniferous and later periods have not been subjected to the heat, pressure, and earth movements necessary to produce slate, and as at present found are in the form of plastic clay, suitable for the manufacture of bricks and tiles. The oldest English tile clays—those of Staffordshire and Shropshire—belong to the Carboniferous period : coal is of the same period.

The common ancestry of slates and tiles is conveniently shown in " family-tree " form, as in Fig. 3.

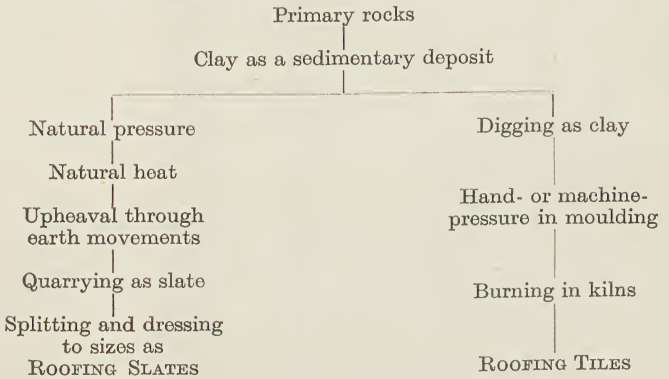


Fig. 3.—Relationship of slates and tiles

It might be said that while slates and tiles are both made of clay, in the case of slates, Nature has done the pressing and burning for us ; in the case of tiles, we have to perform these processes for ourselves.

Sources of Supply

The principal sources of supply of roofing slates in England and Wales are shown in the accompanying map (Fig. 5). Very little usable slate occurs east of any of the places shown.

Slate from Bangor and Portmadoc

The largest groups of quarries, producing slates unsurpassed for durability and regularity, are in the Bangor and Portmadoc districts of North Wales. By reason of their evenness of grain they are easily split and cut to regular sizes, and this quality, coupled with the fact that the slate deposits are so enormous, has caused Bangor and Portmadoc to become the largest slate-producing centre in the world. It should be explained that Portmadoc slates are actually quarried at Festiniog : Portmadoc is the seaport from which they were formerly—and still are, but in much smaller quantities—shipped.

In the Bangor district the slate usually lies near the surface, and can be

Photochrom Co. Ltd.

Fig. 4.—PENRHYN QUARRY—ROCKMEN AT WORK

quarried from an open face. Portmadoc slate lies well underground, and has to be mined. Bangor slates are generally of a purplish colour, but the shades range from red to dark blue. Portmadoc slates are of a greyish blue. The sizes to which Bangor and Portmadoc slates are ordinarily dressed are given in the Table on page 217. Other sizes, if not too large, can be made to order.

Westmorland Slate

The term "Westmorland" is loosely applied to the coarse-grained slates, green and variegated in colour, that are produced in the Lake District, and includes those from Cumberland, Westmorland, and even some from Lancashire. Westmorland slates have a cleavage plane which is less clearly defined than that of ordinary Welsh slate, and the products of these quarries cannot usually be split to such a degree of thinness, nor are they so easily produced in standard sizes. Hence Westmorland slates are nearly always sold in what are known as random sizes, varying from 26 in. by 14 in. down to 12 in. by 6 in. or even smaller. The quarries are of both kinds, open face and underground. The cost of producing these slates is enormous, but connoisseurs of roofing materials are satisfied that the extra cost is well worth while. Buttermere random slates, in the opinion of many architects, are the most beautiful roof covering it is possible to use.

Prescelly Slate

Prescelly slates are produced in the south-west of Wales—the Pembrokeshire corner. A glance at the map will show that Prescelly is a link

in the chain of slate quarries that runs from south to north along the western seaboard of England and Wales from Cornwall, through south-west and north-west Wales and Lancashire, to Westmorland and Cumberland.

Prescelly slates are coarse in grain, but rather smoother than Westmorland, not easy in cleavage, and very variable in colour. Hence Prescelly slates, like Westmorland, are usually sold in random sizes. The colours range from blue to red and green.

Fig. 5.—Map of the slate quarries of England and Wales

Cornwall Slate

The most important Cornish quarry is that at Delabole: in fact, it is claimed for the Old Delabole Slate Quarry that it is the largest open quarry and the oldest continuously worked quarry in England and Wales. The slates are coarse in grain, green, grey-green, and rustic in colour, and mainly of random sizes. A few sized slates of the ordinary Bangor and Portmadoc sizes are produced, and some of random width but even length. The appearance of each kind—standard sizes, random widths, and randoms—is well shown in Figs. 9A, 9B, and 9C.

Random-width slates form an attractive roof covering that is hardly distinguishable from one which is composed of random slates laid in diminishing courses. An advantage of using random widths is that the battening is of even gauge throughout, and has not to be diminished in its progress from eaves to ridge, as for random sizes.

Colour of Slate

The colour of slate has usually no relation to its quality, but it has, of course, a "sales value." The quality of a slate depends upon properties that are not indicated by the colour of the rock. The question is fully discussed by Dr. F. J. North in his handbook *The Slates of Wales*, published at 6*d*., plus postage, by the National University of Wales,

Photochrom Co. Ltd.

Fig. 6.—PENRHYN QUARRY—THE UPPER QUARRY

Cardiff. This book contains an excellent and detailed description of the formation of the Welsh slate beds.

Quality, Weight, and Thickness

Slates are often listed as firsts, seconds, and thirds, but these terms have not here the same significance as when used in reference to tiles.

First Quality				*Second Quality*			
Size	*Computed Weight per 1,200*	*Price per Mille*		*Size*	*Computed Weight per 1,200*	*Price per Mille*	
		Blue	*Green and Wrinkled*			*Blue*	*Green and Wrinkled*
in. *in.*	*cwt.*	*s.* *d.*	*s.* *d.*	*in.* *in.*	*cwt.*	*s.* *d.*	*s.* *d.*
24 × 12	56	700 0	668 0	24 × 12	76	685 0	644 0
20 × 10	36	445 0	420 0	20 × 10	50	462 0	418 0
18 × 9	29	314 0	303 0	18 × 9	40	304 0	298 0
16 × 8	23	247 0	237 0	16 × 8	32	240 0	218 0

The grading refers rather to the thickness and weight than to the actual quality or durability of the slate. A seconds Welsh slate is generally thicker and coarser than a firsts from the same quarry, and hence heavier because it is split from a coarser vein. In practice, the seconds will usually prove quite as durable as the firsts, and perhaps more robust. On p. 214 are a few extracts from the comprehensive Penrhyn slate quarry list, showing weights and prices of first- and second-quality slates of a few of the sizes made by this, the largest of the Welsh quarries. When laid on the roof, the costs of the two qualities work out much the same, the amount saved in initial cost for seconds being counterbalanced by the extra cost of carriage, the seconds being so much heavier per mille than the firsts.

Fig. 7.—OAKELEY QUARRY—QUARRYMAN DRILLING UNDERGROUND WITH PNEUMATIC HAMMER

Calculations for Quantities

All slates are laid similarly to plain tiles; that is, with a double lap. Each slate overlaps the slate in the next course but one below it (Fig. 10). There are thus two

Fig. 8.—OAKELEY QUARRY—ENTRANCE TO UNDERGROUND WORKINGS, SHOWING SLATE CHAMBER AND PILLAR LEFT TO SUPPORT THE SUPERIMPOSED MOUNTAIN

Fig. 9A.—OLD DELABOLE SLATING—SLATES OF REGULAR SIZES

thicknesses of slate in all parts of the roof, and three in most parts.

Sized Slates

The sizes of slates in common use range from 12 in. by 6 in. up to 24 in. by 12 in. and even 24 in. by 14 in. The practice of specifying any kind of roofing material by its gauge alone is bad, but it is particularly so in slating: it is always better to specify the lap. The standard minimum lap for plain tiling is $2\frac{1}{2}$ in. For slating, roof pitches are on the average lower, and the standard minimum lap has come to be recognised as 3 in. In any specification for slating, the size of slate and the lap should be stated.

The length of a slate on the roof may be considered as made up of twice the gauge plus the lap. In Fig. 10 we have an 18-in. by 9-in. slate laid to a 3-in. lap, and the gauge is therefore (18 in. — 3 in.) ÷ 2, or $7\frac{1}{2}$ in. To find the number of slates per square we divide the exposed area of each slate (in this case 9 in. by $7\frac{1}{2}$ in.) into one square of 100 ft. super. It is usually convenient in these calculations to work in inches, and our calculation of the number of 18-in. by 9-in. slates laid to a 3-in. lap required to cover a square becomes :—

$$\frac{14{,}400}{7\frac{1}{2} \times 9'} \text{ or } 213.$$

By a similar process it will be found that the number of 16-in. by 12-in. slates laid to a $3\frac{1}{2}$-in. lap required to cover one square is $\frac{14{,}400}{6\frac{1}{4} \times 12}$ or 192.

Fig. 9B.—OLD DELABOLE SLATING—RANDOM-WIDTH SLATES OF A STANDARD LENGTH LAID TO A REGULAR GAUGE

Calculating the Number of Slates Required

The following Table gives the number of slates of each of the ordinary sizes required to cover one square for 2½-in., 3-in., and 3½-in. laps. It also gives the old names for some of the sizes. (These names are rapidly dying out, and nobody really regrets their passing: it is undignified to speak of a Wide Countess or a Narrow Lady. Nowadays no countesses are wide, and all ladies are narrow.) But it is useful to know the names, as they do still appear in some specifications.

Size in Inches	*Name*	*Number per Square When Laid to a*		
		2½-in. Lap	*3-in. Lap*	*3½-in. Lap*
24 × 14	Princesses	96	98	100
24 × 12	Duchesses	112	114	117
22 × 12	Small Duchesses	123	126	130
22 × 11	Marchionesses	134	138	142
20 × 12	Wide Countesses	137	141	145
20 × 10	Countesses	165	169	175
18 × 12		155	160	166
18 × 10	Wide Viscountesses	186	192	199
18 × 9	Viscountesses	206	213	221
16 × 12		178	185	192
16 × 10	Wide Ladies	213	222	230
16 × 9	Broad Ladies	237	246	256
16 × 8	Ladies	267	277	288
14 × 10	Headers	250	262	274
14 × 8	Small Ladies	313	327	343
14 × 7	Narrow Ladies	358	374	392
12 × 6	Small Doubles	505	533	565

Fig. 9c.—OLD DELABOLE SLATING—RANDOM SLATES LAID IN DIMINISHING COURSES

How Slates Are Sold—the Cover per 1,000

It is here necessary to digress for a moment to explain the methods by which slates are sold. Sized slates are sold at the quarry by the mille of 1,200. An order to a quarry for 3,500 slates would be interpreted as meaning three and a half times 1,200, or 4,200 actual slates. They are now usually retailed by slate merchants to builders by actual count; that is to say, 1,000 slates are sold as 1,000 actual count. In this article, "mille" means 1,200 and "thousand" or "1,000" means 1,000.

The cover per 1,000 is found by multiplying the exposed area of each slate by 1,000. The cover per 1,000 for a 16-in. by 10-in. slate laid to a 3-in. lap would therefore be :—

$$10 \text{ in.} \times 6\tfrac{1}{2} \text{ in.} \times 1{,}000 = 4{\cdot}52 \text{ squares.}$$

The cover per mille would be :—

$$10 \text{ in.} \times 6\tfrac{1}{2} \text{ in.} \times 1{,}200 = 5{\cdot}42 \text{ squares.}$$

There is a very simple method, not very well known, of finding the cover per mille. Suppose that a 16-in. by 12-in. slate is to be laid to a 3-in. lap. Then the gauge is $6\frac{1}{2}$ in., and the cover per mille is $6\frac{1}{2}$ squares. The cover per mille in squares for a slate 12 in. wide is always the same as the gauge in inches. The reason is easy to see. The cover per mille for a 16-in. by 12-in. slate laid to a 3-in. lap is $12 \times 6\frac{1}{2} \times 1{,}200$ sq. in. =

$$\frac{12 \times 6\frac{1}{2} \times 1{,}200}{14{,}400} \text{ squares.}$$

Cancellation of this fraction leaves only the $6\frac{1}{2}$.

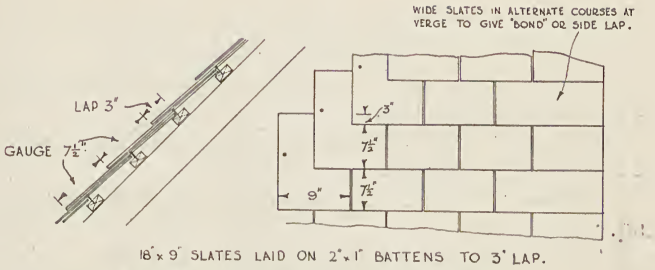


Fig. 10.—GAUGE AND LAP IN SLATING

Then, for a 10-in. slate the cover will be five-sixths of that given by a 12-in. slate of the same length. Hence the cover for a 16-in. by 10-in. slate laid to a 3-in. lap would be five-sixths of 6·5 squares, or 5·42 squares.

One more example will make the point quite clear. What would be the cover in squares per mille of an 18-in. by 9-in. slate laid to a 3½-in. lap ?

$$\text{Gauge} = (18 \text{ in.} - 3\tfrac{1}{2} \text{ in.}) \div 2 = 7\tfrac{1}{4} \text{ in.}$$

Then cover per mille for 18-in. by 12-in. slate = 7·25 squares,
∴ cover for 18-in. by 9-in. slate = ¾ of 7·25, or 5·44 squares.

Random Slates

Random-sized slates are of unequal length and width : generally, the longer a slate the wider it is, so on a roof covered with " randoms " the largest slates, which are always fixed in the lowest courses, may measure 26 in. by 14 in., and the smallest, in the top courses, 12 in. by 6 in. or even smaller. The intermediate courses grade downwards gradually between these extremes.

Slates of random widths have been mentioned above, and the distinction between the two kinds of randoms should be kept clear in the reader's mind, and the points about battening noted. For random-width slating the whole roof can be battened at once : where random-sized slates are to be used the carpenter cannot batten until the slater has given him the spacing for each course, and the slater cannot do this until he has sorted the slates into sizes on the job.

Peggies are small randoms of lengths from 8 in. up to 12 in. or 14 in., and of irregular widths.

Random slates of all kinds are sold by the ton. The covering capacities cannot be worked out by the purchaser, but all quarry owners who make such slates issue lists showing covering capacities per ton. Considerations of space forbid the reproduction of full lists here, but following are short extracts from two such quarry lists. It should be noted that the computed covers per ton are averages, and cannot be guaranteed accurate for any particular consignment.

Examples of Covering Capacity of Westmorland Random Slates

Random sizes, Buttermere Light Green.

Bests : 24 in. to 12 in., in proportionate widths, computed cover 27–28 sq. yd. per ton.

Seconds : 24 in. to 12 in., in proportionate widths, computed cover 21–22 sq. yd. per ton.

Thirds : 20 to 10 in. in proportionate widths, computed cover 15–16 sq. yd. per ton.

The computed *weights* for bests, seconds, and thirds of these slates work out at about 8, 10¼, and 14½ cwt. per square. Note that these slates follow the general rule in slates : the lower the quality, the thicker the slate, so in practice, although the bests given above cost more per ton than the seconds, we get better cover per ton, and the seconds, when laid on the roof, cost about as much as the bests.

The Buttermere Light Green is one of fourteen kinds listed by the Westmorland Green Slate Quarries Ltd, Keswick, Cumberland.

Delabole Randoms

Randoms for laying in graduated courses, Rustic Reds (25 per cent.) and Weathering Grey-Greens (varied mixed shades), 3-in. lap.

No. 1 *Grading :* 24-in. to 12-in. lengths, cover per ton 2·50 squares.

No. 2 *Grading :* 22-in. to 12-in. lengths, cover per ton 2·25 squares.

No. 2*a Grading :* 16-in. to 12-in. lengths, cover per ton 2·25 squares.

Random widths, ordinary grey-green, No. 1 grading :—

Length (× *Random Widths*)	*Cover in Squares per Ton*
20 in.	2·38
18 in.	2·37
16 in.	2·37
14 in.	2·44

Here is a point for careful note. As a general rule, the larger the slate the thicker it is : it is possible to cut a slate of small area to a lesser thickness than one of larger area. This explains why, say, the No. 1 grading in Delabole randoms, ranging from 24 in. to 12 in., gives much the same cover per ton as the No. 2*a* grading, which ranges from 16 in. to 12 in. If all the slates, large and small, were of the same thickness, the No. 1 grading would give by far the better cover, because with large slates less of the roof is covered with three thicknesses of slate than with small slates. The lesser thickness of the small slates just about compensates for the extra area covered with three thicknesses, and as a result the cover per ton given by large and small slates is about equal.

Calculations for Battening

For sized slating and for tiling, the calculations for battening are simple. If battens are fixed on a roof at 12-in. intervals, centre to centre, then on one square of roof there will be 100 ft. run of battens. If the spacing or gauge is 6 in., there will be 200 ft. run to the square. The rule is : Divide 1,200 by the gauge in inches. The following Table gives the number of feet run per square for various gauges, and will be found useful for both slating and tiling :—

Gauge in Inches	*Feet run of Battens per Square*	*Gauge in Inches*	*Feet run of Battens per Square*
3½	343	7½	160
3¾	320	8¼	146
4	300	8½	141
4¼	283	9¼	130
4½	267	9½	127
5	240	10¼	117
6	200	10½	114
6¼	192	12	100
6½	185	13	92
7¼	166	13½	89

The battening for random-sized slates cannot be accurately calculated. For 24-in. to 12-in. random slating an average is 190 ft. to 200 ft. per square, but the actual figure depends upon the proportions of large and small slates in a consignment.

PART II.—WOOD SHINGLES

WOOD shingles are becoming increasingly popular in England, and this is not surprising, in view of their suitability for buildings in well-wooded country districts. Two objections are frequently raised when shingles are put forward as a suitable covering for domestic work : their non-durability, and their non-resistance to fire.

The durability of wood shingles is much greater than is popularly supposed ; there are many shingled roofs of oak or cedar in England and Wales that have stood for forty years and more, and are still perfectly sound. The risk of fire is also greatly exaggerated. In British Columbia, where red-cedar roofs are universal, fires that originate in the roof are exceedingly rare. If desired, the shingles can be coated with a fire-preventive paint.

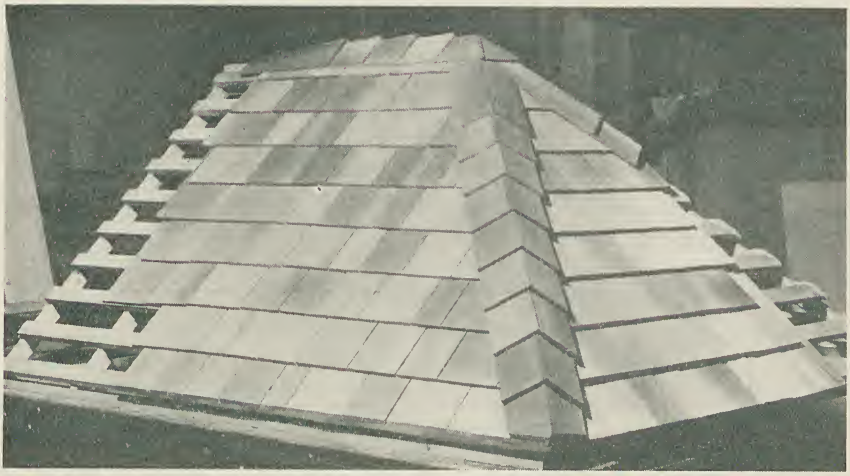


Fig 11.—CANADIAN RED CEDAR SHINGLES ON OPEN BATTENING AT 5-IN. GAUGE, SHOWING FORMATION OF RIDGE AND HIPS. (*W. H. Colt Ltd.*)

Types

Shingles are commonly of English oak or imported cedar, the former being the more expensive. The photographs illustrating this article are of Canadian red cedar-wood shingling supplied by Messrs. W. H. Colt Ltd., to whom we are also indebted for much of the following information regarding fixing.

Size

Cedar-wood shingles are 16 in. long, $\frac{2}{5}$ in. thick at the butt, tapering to the top. The widths vary from 4 in. to 12 in. A 5-in. exposure (or gauge) is satisfactory for all pitches down to 30°; for slower pitches the gauge should be decreased.

Shingles are sold in bundles, the covering capacity being as follows :—

At	$3\frac{3}{4}$-in.	gauge	one	bundle	covers	19·2	sq.	ft.
,,	5-in.	,,	,,	,,	,,	25·7	,,	,,
,,	$5\frac{1}{2}$-in.	,,	,,	,,	,,	28·3	,,	,,
,,	$7\frac{1}{2}$-in.	,,	,,	,,	,,	38·5	,,	,,

The cost is 12*s*. per bundle, carriage paid to nearest railway station. The $7\frac{1}{2}$-in. gauge is recommended only for vertical shingling.

Weight

The weight of a square of shingling is approximately one-tenth of the weight of a square of plain tiling : an ordinary specification for a shingled roof calls for 2-in. by 3-in. rafters at 2-ft. centres, and 1-in. by 2-in. battens at 5-in. centres.

Nailing

Shingles are not holed for nailing: the nails are driven directly into the shingles at about 1 in. from the edge, and about 1 in. above the gauge line (that is to say, about 6 in. from the butt). The heads should not be driven into the wood. The nails may be ordinary galvanised slate nails, $1\frac{1}{2}$ in. long and of No. 12 or 13 gauge.

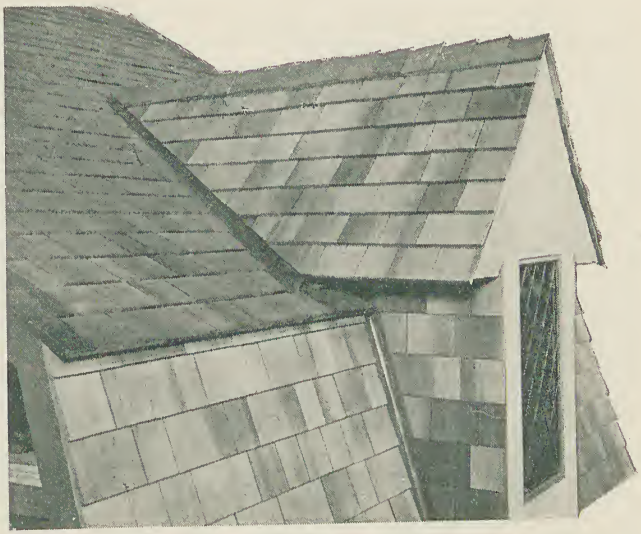


Fig. 12.—VERGES, RIDGES, ABUTMENTS, VALLEYS, AND VERTICAL WORK IN RED CEDAR SHINGLING. (*W. H. Colt Ltd.*)

Laying

Fig. 11 illustrates the method of laying. A double course is laid at the eaves, as in plain tiling, projecting about 2 in. beyond the fascia. In continuing with the courses up the roof, care should be taken that a minimum side lap of $1\frac{1}{2}$ in. is given, but no attempt should be made to sort the shingles into widths. If they are used directly from the bundles, the correct random effect will be obtained. A gap of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. should be allowed between adjacent shingles.

Hips and Ridges

Hips and ridges are best formed from the shingles themselves, using shingles of an even width of, say, 4 in. Wider ones may have to be cut down for this purpose. The method of butting the ridges at edges and overlapping at ends is clearly shown in Fig. 11. Lead or felt is not needed at ridges and hips. Alternatively, hips and ridges may be boarded, using timber not less than 4 in. wide.

Verges and Abutments

Wide shingles should be used in alternate courses at verges and abutments, as in Fig. 12.

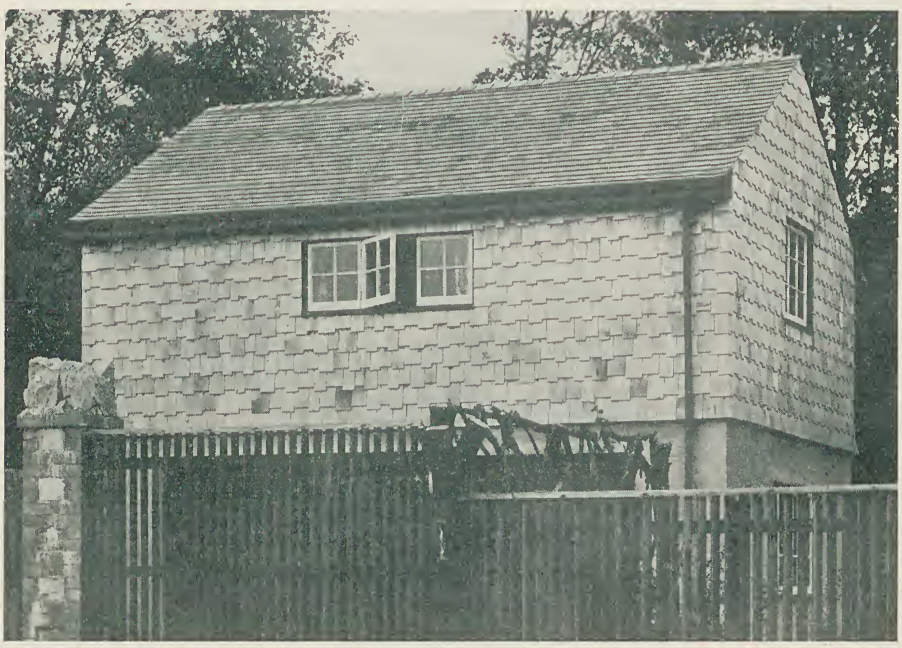


Fig. 13.—STAGGERED COURSES IN VERTICAL SHINGLING. (*W. H. Colt Ltd.*)

Valleys

Valleys are formed with lead in the same way as for a tiled or slated roof. A good width of lead, say 15 in., should be used, with no tilting fillet.

Walls

In Fig. 13 is shown a small building of which the walls have been shingled in staggered courses : this variation in method may also be employed for roofs. The gauge on vertical work may be increased to $7\frac{1}{2}$ in., to which exposure the shingles on the mansard and vertical work of Fig. 12 have been fixed.

Colour

Both oak and red cedar-wood shingles improve greatly in appearance after a few months' exposure to the weather. The original red tinge of the latter changes to an attractive silver-grey. If any special colour is desired a good creosote stain should be used, but the user who dislikes the first appearance of a shingled roof is strongly recommended to wait until the roof has weathered before finally deciding whether or not to stain.

PITCHED-ROOF COVERINGS

PART III.—CLAY TILES

CLAY suitable for the manufacture of roofing tiles is widely distributed over England, the largest deposits being in the Broseley district of Shropshire, North and South Staffordshire, Berkshire, the Bridgwater district of Somerset, and the south-east corner of England. The clays vary in their mineralogical and chemical compositions, and it is these variations that account for the different characteristics of the tiles produced. The Midland clays, those of Broseley and Staffordshire, for example, contain a high percentage of iron, and the tiles made in those districts can be naturally burnt to purple, brown, and blue colours that cannot be approached in tiles made in some other parts of the country, except by the application of artificial colouring.

Again, some clays are eminently suitable for the manufacture of only plain tiles, and others can be used as well for the production of larger units such as pantiles, Roman tiles, and single-lap tiles generally. It is, in fact, considered that tiles such as the Bridgwater Double Roman, Marseilles, and other types that depend for their effectiveness upon the roof on trueness to shape, can be made only from alluvial clays of recent deposit. However that may be, it is true that such tiles are successfully made only from those clays.

A discussion of the technicalities of clay, and the suitability of each kind for the manufacture of either bricks or tiles or both, is outside the scope of these articles, but the reader should remember that there are nearly always very good reasons for the production of one kind of tile instead of another in any particular district. These reasons are usually technical, but often they form part of the fascinating history of the development of the English roofing tile.

Manufacture

In all branches of clay-working the essential processes are the same : the raw material has to be reduced to a condition of plasticity in which moulding becomes possible—sometimes by hand, sometimes by machinery —and the moulded shape has to be given permanence by the application of heat. Only the briefest of outlines of these processes is possible here.

Pure clay consists of silica, alumina, and combined water in the approximate proportions 47, 40, and 13 ; some china clays approach this standard of purity. For brick and tile making such a clay is not

necessary, nor, indeed, would it be suitable ; various impurities are always present, and these, as we have hinted above, account for the variations in quality, texture, and colour among roofing tiles made in different districts.

Digging is the first in the series of manufacturing processes : so simple and obvious a matter, one would think, as to be hardly worth a mention. In practice, digging is an immensely important operation, and one that calls for considerable skill, since usually two or more kinds of clay, of different qualities and characteristics, are present in a clay pit, and these kinds have to be mixed in carefully calculated proportions if the best possible tile is to be produced.

Weathering consists in allowing the clay to remain in the open for a period long enough to ensure the thorough disintegration of the clay. Frost is the greatest of all the disruptive agents that can be applied to clay, hence a winter's weathering is essential to most clays.

Pugging and Grinding

The weathered clay is thoroughly incorporated in a pugmill, mixed with water, and ground between rollers to the consistency required for moulding. The consistency depends upon the kind of tile to be produced, that is, whether hand- or machine-made. For hand moulding, a high degree of plasticity is necessary : the clay used for the manufacture of some kinds of machine-made tiles is reduced only to a semi-dry state.

Moulding

Moulding follows pugging and grinding, and may be done either by hand or by machinery. The term " hand-made sand-faced tile " will be familiar to most readers. The origin of the term serves to illustrate one of the fundamental differences between hand- and machine-made tiles. Hand-made tiles are necessarily made from plastic clay, because a moulder cannot manipulate a stiff clay. It is pressed into a mould of the same shape as the finished tile—but larger, to allow for shrinkage in burning—and the moulder, before filling his mould, sprinkles sand on it to make the clay come more easily from the mould : hence the " sand-face." In the manufacture of machine-made tiles this use of sand is not necessary, since the clay is not in a highly plastic condition. Machine-made sand-faced tiles are now made in emulation of the hand-made article, but here the sand is added after the tile is made and is not a necessary feature of the process of manufacture.

Drying

Moulding is followed by drying in specially built and usually heated sheds. During drying a large percentage of the water contained in the " green " tile is removed by evaporation. The time occupied by drying depends mainly upon the weather, the temperature of the drying shed,

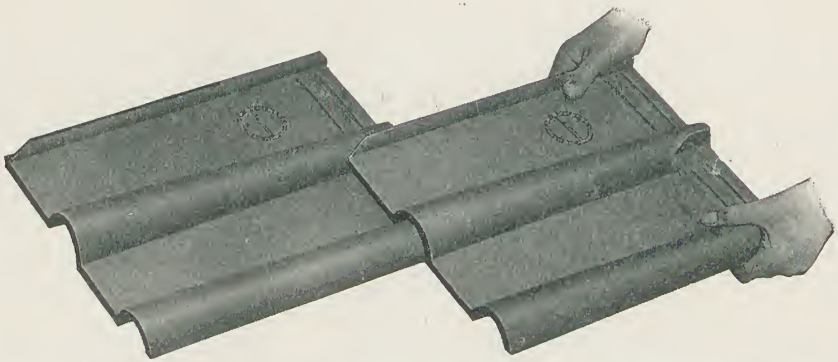


Fig. 1.—BROKEN-JOINT SINGLE-LAP TILING—DOUBLE ROMAN INTERLOCKING TILES. (*Colthurst, Symons & Co. Ltd.*)

and the plasticity of the "green" tile. Hand-made tiles naturally require longer in the drying shed than does the machine-made article.

Firing

Firing is the last and perhaps the most important of the processes through which the tile goes. Methods of firing vary in different parts of the country, partly on account of differences in the kinds of clay, and partly because in some districts tiles are burnt alone in a kiln, and in others are mixed in the kiln with bricks or other goods. The burner is probably the most skilled man in a tile works : he has to judge within very narrow limits when to accelerate the heating of the kiln, how long to apply the full heat, and when to start cooling down. The old-time burner, who had no electrical recording apparatus to tell him the temperature inside the kiln, showed amazing skill in these matters.

The length of time occupied in firing tiles varies according to the class of tile, and to a certain degree upon the weather, but an average period is a fortnight.

Sorting

Upon being taken from the kiln, tiles are sorted into best, second, and third qualities. Best tiles should be without a fault of any kind ; seconds tiles, as sent out by most works, are those which have some fault which precludes their ranking as best tiles, but which is not detrimental to the tile as a roof covering. Tiles that are slightly out of true, or have an unsightly "flash" or other blemish on their surface, are classed as seconds. Third-quality tiles are usually either badly twisted or fire-cracked "above the gauge line," as the tiler says. If a personal view may be given, the author would say that no tile which cannot fairly be classed as a best or second should be used for roofing. Since there is admittedly to-day over-production of clay tiles, it would seem that makers

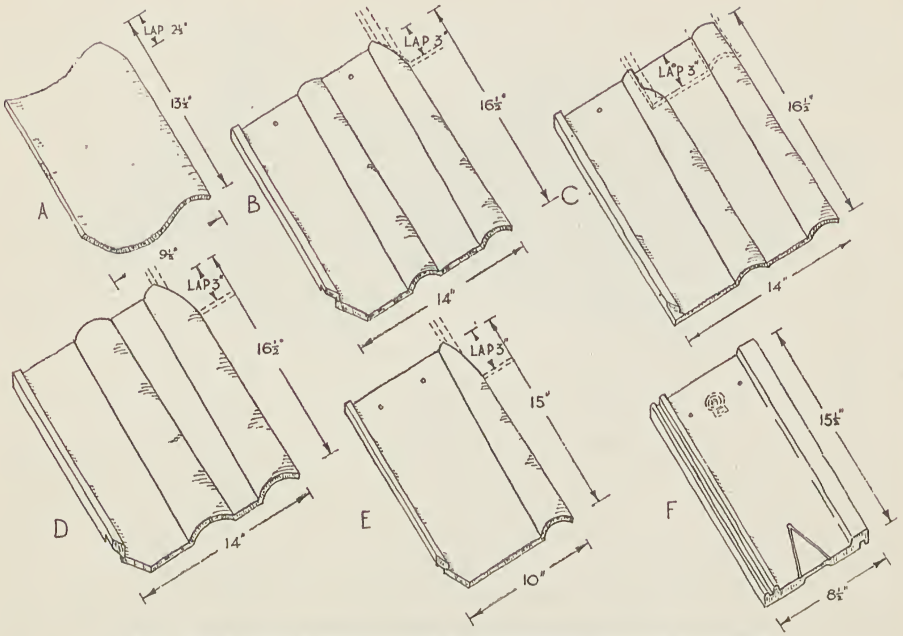


Fig. 2.—A FEW POPULAR FORMS OF ENGLISH SINGLE-LAP TILE

A. Old English pantile. B. Double Roman tile—straight joint. C. Double Roman tile—broken joint. D. Reynardo tile. E. Single Roman tile. F. Somerset interlocking tile—No. 13.

would benefit if all third-quality tiles were destroyed, and the reputation of English clay tiles would to that extent be enhanced.

Classification of Tiles

For practical purposes, tiles are most conveniently classified as single-lap and double-lap or plain.

In single-lap tiling each tile overlaps or is overlapped by the tiles on either side of it in the same course, and the tiles in the courses above and below. There is thus only one thickness of tile in most parts of the roof, and two thicknesses in some parts. Single-lap tiles may have a simple overlap, as in the case of the English pantile (Fig. 2), or there may be an interlock at the head or at the side and head. The Somerset interlocking No. 13 (Fig. 2) has a side lock. The imported interlocking improved pantile (Fig. 5) has both side and head locks.

In double-lap or plain tiling, each tile overlaps the tile in the next course but one below it, but there is no overlap at the side. The length of tile exposed on the roof is called the gauge, and the amount by which one tile overlaps the tile in the course next but one below it is called the lap. In plain tiling, it will be noted, there are at least two thicknesses of tile in every part of the roof, and three thicknesses in most parts.

Illustrations of a number of kinds of single-lap tiles are given in Figs. 2, 3, 4, and 5, and in the notes that follow a brief description of each will be found. The approximate sizes, covering capacities, and gauge for battens of each are given. Users are advised to wait until tiles are delivered before fixing the battens, as in certain cases slight variations in length as between one consignment and another may occur.

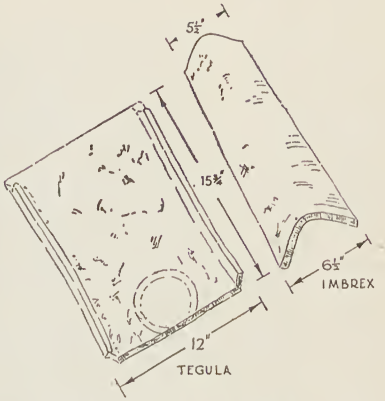


Fig. 3.—ROMAN TEGULA AND IMBREX

Old English Pantile

The English pantile (Fig. 2) is a descendant of the Spanish tile (see Fig. 4), also called the over-and-under tile and Spanish Mission tile. It is probable that the Flemings first evolved this single tile, consisting of a channel and a roll, out of the two units that make up the Spanish tile. The pantile is justly popular, as it fits admirably into the modern architectural picture. It is made in many parts of the country, Bridgwater, Berkshire, and East Anglia being the largest centres of production.

The following data are subject to much variation, as the pantiles made by different works are dissimilar in both length and width.

Size : 13½ in. by 9 in. Cover : 150 per square. Gauge for battens : 12 in.

Double Roman Tile

The Double Roman tile (Fig. 2) is a product of the Bridgwater district of Somerset, and is the largest tile in use in England. It is a descendant of the Roman *tegula* and *imbrex* (Fig. 3), which the Romans used extensively in England for their villa roofs. In the Double Roman tile, two *tegulæ* and two *imbrices* are combined into one unit.

Technical Data.—Size : 16½ in. by 14 in. Cover : 85–90 per square. Gauge for battens : 13½ in.

Single Roman Tile

This is the smaller, and not so popular, brother of the Double Roman tile, and is a little closer to the line of descent from the *tegula* and *imbrex*. It also is a product of Bridgwater, although a nearly similar type is made in Lincolnshire. A larger type, equal in size to the Double Roman, is also made.

Technical Data.—Small Pattern. Size : 15 in. by 10 in. Cover : 125 per square. Gauge for battens : 12 in. *Large Pattern.* Data as for Double Roman.

Double Roman Interlocking

This tile has the same appearance as the ordinary Double Roman tile on the roof, but is laid with a broken joint. The ordinary Double Roman is laid with a straight joint. (See Fig. 2.) The practical advantage of the broken joint is that the water running down the side channel of any one tile is discharged on to the face of the tile below, and not, as in the case of the straight-joint tile, into the side channel of the tile below. (See also Fig. 1.)

Technical Data as for Double Roman tile.

Somerset Interlocking Tile No. 13

A very effective tile (Fig. 2), manufactured expressly for cheap domestic or industrial roofing. It is of adjustable lap, and has been used without felt on roofs as low as 30° of pitch at the eaves. This tile is produced by the Somerset Trading Co. Ltd., Bridgwater.

Technical Data.—Size : 15½ in. by 8 in. Cover for 3-in. lap, 155 tiles per square. Gauge for battens for 3-in. lap : 12½ in.

Reynardo

The Reynardo (Fig. 2) is essentially a Double Roman tile, but it has a bolder roll, and on the roof an appearance somewhat similar to that of the Spanish tile. The Reynardo tile is an exclusive product of Messrs. Colthurst, Symons & Co. Ltd., Bridgwater.

Technical Data as for Double Roman tile.

Spanish Tile

The tiles are laid alternately concave and convex in courses, and there is a lap at both sides and at the head of each tile (Fig. 4).

Technical Data.—There are many makes of Spanish and Italian tile, all of different size and covering capacity, and users should obtain information from the manufacturers concerned.

Italian Tiles

Similar in type to the Spanish tile, with this difference—that the under tile is flat instead of concave. This distinction between Italian and Spanish tiles is not generally understood, and cases have occurred where a specification has called for Spanish tiles when Italian tiles were meant.

Both kinds are expensive, but eminently suited to buildings where a bold, vertical roll on the roof is required to heighten the effect of the general elevation.

Courtrai-du-Nord Tile

This tile, shown in Fig. 5C, was once known in England only as a cheap but effective roof covering. It is now made in a great variety of colours, both matt and glazed : meadow green glazed, bluish green glazed, tea-

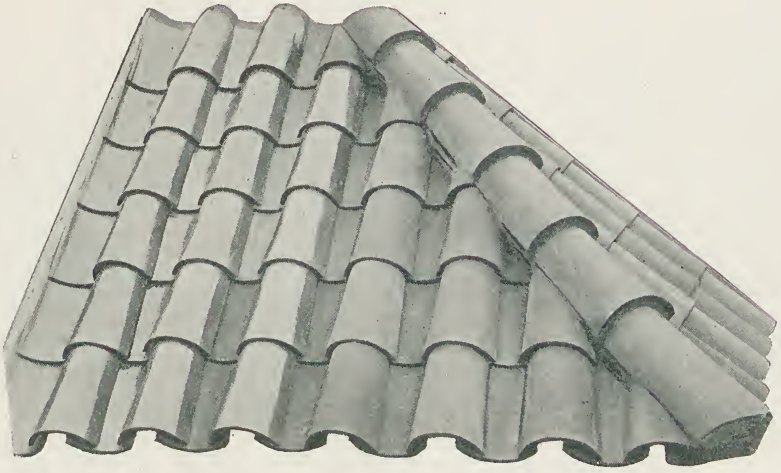


Fig. 4.—SPANISH TILING—SHOWING USE OF TAPERED HIPS. (*Colthurst, Symons & Co. Ltd.*)

pot brown glazed, autumn leaf glazed, moss green, and lichen green are a few of the colours listed by the importers, Messrs. Langley London Ltd.

Technical Data.—Size : 11½ in. by 8½ in. Cover : approximately 208 tiles per square. Gauge for battens : approximately 9⅜ in.

Improved Interlocking Pantile

This (Fig. 5A), like the Courtrai-du-Nord tile, is of Continental make, and obtainable in a variety of colours, both matt and glazed. Comparison with Fig. 2 shows that it differs from the ordinary English pantile principally in the fact that the interlocking improved pantile has a side and head lock. For technical reasons this type of pantile has not so far been made in England.

Technical Data.—Size : 13¼ in. by 9¾ in. Cover : approximately 147 tiles per square. Gauge for battens : approximately 11½ in.

The Cloister Tile

This is designed to give on the roof an effect somewhat similar to that of Spanish or Italian tiling (Fig. 5B).

Technical Data.—Size : 11¾ in. by 8½ in. Cover : approximately 200 tiles per square. Gauge for battens : approximately 9⅞ in.

Plain Tiles

Fig. 6 illustrates the ordinary two-holed, two-nibbed plain tile, and the fittings that are used with it for roofing and vertical tiling. Two sections of half-round ridge are shown : 90° pitch for main ridges, and 105° for hips. The 90° ridge is too bold for use on hips, and its use for that purpose makes an awkward intersection at the point where the main ridge and hip meet.

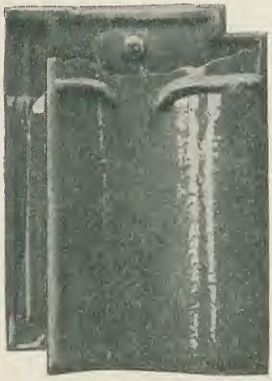


Fig. 5A.—IMPROVED INTERLOCKING PANTILE

Fig. 5B.—CLOISTER TILE

Fig. 5C.—COURTRAI-DU-NORD TILE

Langley, London Ltd.

CALCULATIONS

Plain Tiling

It is commonly said that a square of tiling requires 600 plain tiles, and although this is a good approximate figure, it is rarely accurate. The standard size of plain tiles is 10½ in. by 6½ in., but in practice sizes vary from 10 in. by 6 in. up to 11 in. by 7 in., and to calculate accurately the number of tiles needed to cover one square we must know (*a*) the size of tile, and (*b*) the lap, or gauge.

The length of each tile when laid on the roof may be considered as made up of twice the gauge plus the lap, and a 10½-in. by 6½-in. tile laid to a 2½-in. lap shows a gauge of 4 in. The number of tiles required to cover one square is clearly the number of times that the exposed area of each tile divides into one square. Thus :—

$$\frac{1 \text{ square}}{6\tfrac{1}{2} \text{ in.} \times 4 \text{ in.}} = \frac{14{,}400 \text{ sq. in.}}{6\tfrac{1}{2} \text{ in.} \times 4 \text{ in.}}$$

$$= 554 \text{ tiles.}$$

Similarly, an 11-in. by 7-in. tile laid to a 3½-in. lap (3¾-in. gauge) will require :—

$$\frac{14{,}400}{7 \text{ in.} \times 3\tfrac{3}{4} \text{ in.}} \text{ or } 549 \text{ tiles.}$$

An 11-in. by 7-in. tile laid to a 2-in. lap (4½-in. gauge), as for vertical tiling, will require only 457 tiles per square.

The following Table gives the number of plain tiles per square required for three sizes of tile laid to various laps. A minimum lap of 2½ in. is recommended for roofing, but 1½ in. is usually sufficient for vertical tiling.

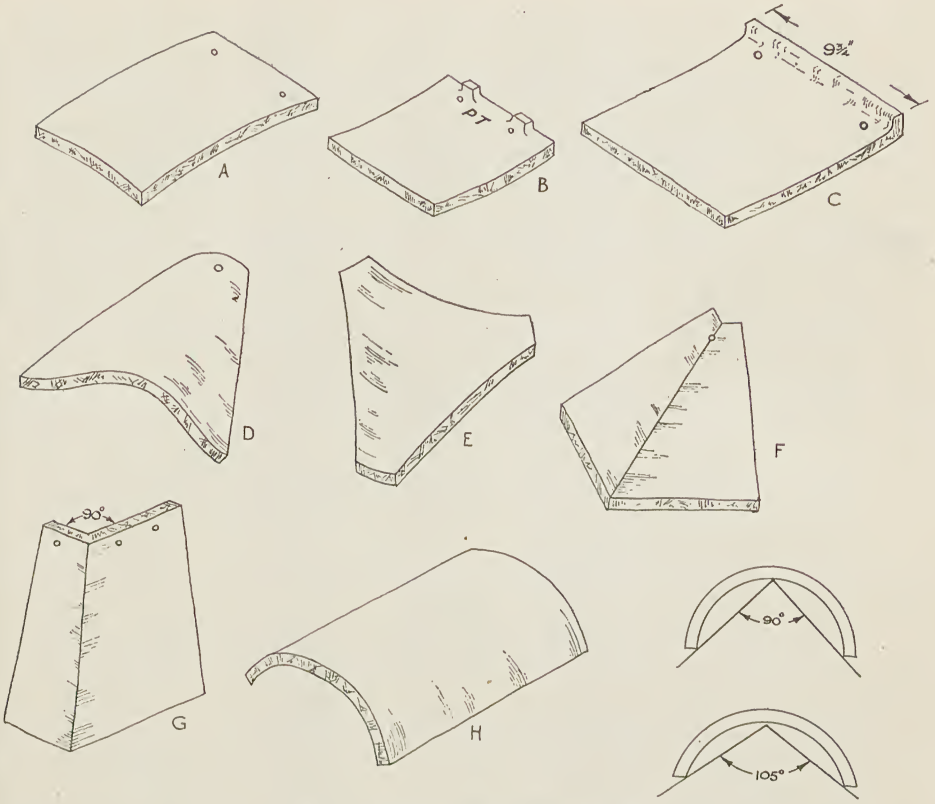


Fig. 6.—PLAIN TILE AND FITTINGS

A. Plain tile. B. Under side of eave tile. C. Under side of tile-and-half tile (continuous nibbed, machine made). D. Bonnet hip tile. E. Valley tile. F. Close-fitting hip tile. G. Angle tile handed, external. H. Half-round ridge tile.

Size of Tile	*Lap in Inches and No. per Square*					
	1½	2	2½	3	3½	4
11 in. by 7 in. . .	433	457	484	514	549	588
10½ in. by 6½ in. . .	492	521	554	591	633	682
10 in. by 6 in. . .	565	600	640	686	738	800

Ridge Tiles

These are usually made in 12-in. or 18-in. lengths, although odd lengths do sometimes occur. The required number is easily obtained.

Bonnet Hips, Hip Tiles, and Valley Tiles

A rough and ready method of calculating the number of these is to take 3 per foot run of hip or valley, but this figure in many cases will allow rather too many for waste. In Fig. 7 the length of the common rafter is 16 ft., and of the hip, 20 ft. The tiles are laid to a 4-in. gauge. If we allow 3 hip tiles per foot, the number ordered would be 60, or 240 for the four hips. The actual net number required for each hip would be 48 or perhaps 49. This is estimated as follows : the number of hip tiles will be the same as the number of courses of tiles on the main slope : a rafter length of 16 ft. gives us, at 4-in. gauge, 48 courses of tiling, and this is the number of hip tiles that will be needed. For the four hips the number would be 49 by 4, or 196, and the tiler would order, say, 204.

The calculations for valley tiles are made similarly.

Angle Tiles

The number of these is estimated similarly by finding the number of courses of plain tiles.

Single-lap Tiling

Here the principle is the same as for plain tiling : divide 100 sq. ft. by the exposed area of each tile, but it must be remembered that the length of each single-lap tile is made up of the gauge plus the lap.

Example.—A single-lap tile measures 16½ in. by 14 in., and has a vertical lap of 3 in., and a side lap of 1½ in. The number of tiles required per square is :—

$$\frac{14{,}400}{13\frac{1}{2} \times 12\frac{1}{2}} \text{ or } 85 \text{ tiles.}$$

These figures are, in fact, those applicable to one of the best known of the English single-lap tiles : the Bridgwater Double Roman tile. The technical data given in the preceding pages for each kind of single-lap tile named have been similarly calculated. Makers or importers will always give this information to customers : the figures are, in fact, almost invariably given in their catalogues.

Weights

The weights of plain tiles are approximately as under :—

10 in. by 6 in. . .	19–21 cwt. per 1,000
10½ in. by 6½ in. . .	20–23 cwt. ,, ,,
11 in. by 7 in. . .	21–25 cwt. ,, ,,

but it is advisable always to get the correct weight from the makers.

Bonnet hips weigh about 3½ cwt. per 1,000 ; angle tiles about 4 cwt. per 1,000 ; and ridge tiles, 12 in. long, about 8½ lb. each.

Fig. 6A.—THE PLAIN TILE IS SUITABLE FOR COMPLICATED ROOFS, HAVING HIPS, VALLEYS, DORMERS, AND SMALL PROJECTIONS

Here we see a roof example of sand-faced plain tiles: "Berroc End," Swinley Forest, near Ascot. (*Architects: Pakington, Enthoven and Grey, FF.R.I.B.A.*)

Fig. 6B.—AN EFFECTIVE EXAMPLE OF A SPANISH-TILED ROOF

"Oldfields Furze," Beaconsfield, Buckinghamshire. View from north-west. White "Snowcrete" walls, black plinth, and black shutters. (*Architect: Langley Taylor, F.R.I.B.A., F.S.I.*)

CHOOSING A TILE

In choosing a tile, the architect has to decide (*a*) the type of tile, whether plain or single-lap, and sometimes (*b*) the kind of tile, whether hand- or machine-made. The following hints may be of assistance to those who have to decide how the roof, the most important single element in an elevation, is to be covered.

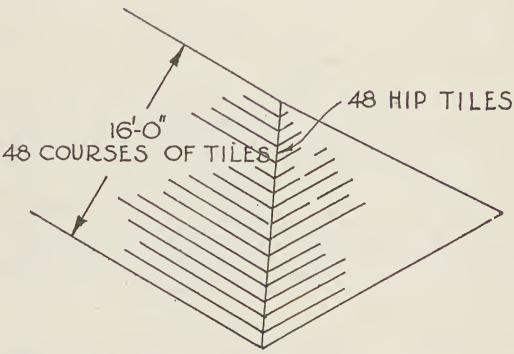


Fig. 7.—ILLUSTRATING METHOD OF CALCULATING NUMBER OF HIP TILES

(1) In single-lap tiling the unit is large, and usually shows a series of well-defined vertical and horizontal lines on a roof. Single-lap tiles are therefore suitable for large and high buildings.

(2) The plain tile is suitable for complicated roofs, having hips, valleys, dormers, and small projections.

(3) Concrete tiles are usually cheaper than machine-made clay tiles of comparable quality, and the latter are cheaper than hand-made tiles.

(4) For slow-pitched roofs the single-lap tile is to be preferred.

(5) Care should be taken to ensure that the tile used is one that can at any time be repeated. Do not, for example, use an imported single-lap tile of which future supplies are not assured.

(6) Remember that if a hand-made tile is chosen, it will " weather " on the roof, but not on the vertical tiling. Machine-made tiles, unless sand-faced, do not usually weather.

(7) If a machine-made clay tile is chosen, one that has been burnt naturally to a dark or brindled shade is preferable to a light-red tile. The latter may laminate ; the former will not. It is not, however, possible to be dogmatic on this point, for the products of some works are light red, however long the period of burning may be.

(8) A well-cambered plain tile should be chosen in preference to a tile that is straight in its length (Fig. 8). The camber not only helps the tail of each tile to sit snugly on the course below, but it provides an air space for ventilation among the tiles and battens. Lamination is hastened by the close bedding of one tile on another for the greater part of its length : capillary action tends to keep the upper surface of one and the lower surface of the other damp for long periods. The circulation of air among plain tiles is assisted if the tile is slightly cambered in its width. Fig. 8 shows a plain tile cambered only in its length, and two kinds of tiles cambered in their length and width.

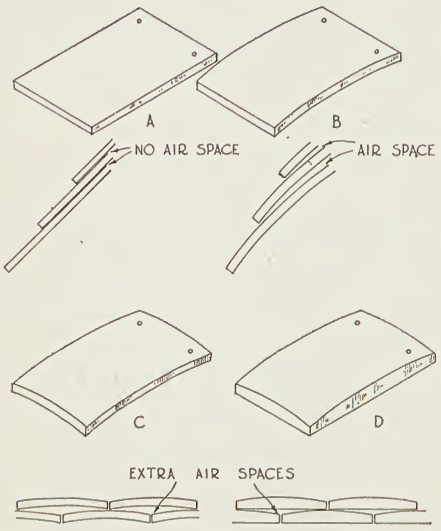


Fig. 8.—A WELL-CAMBERED PLAIN TILE SHOULD BE CHOSEN IN PREFERENCE TO A TILE STRAIGHT IN ITS LENGTH

A. Plain tile straight in its length and width. B. Plain tile cambered in its length only. C. " Full " double-cambered tile. D. " Half " double-cambered tile.

Special Tiles

It often happens that certain fittings—bonnet hips or angle tiles, for example—have to be made of a special pitch for a particular job. In such cases it is advisable to give the works as long notice as possible. Special fittings cannot usually be produced in less than eight weeks from the date of order, and contracts are frequently delayed because the order for the tiles is placed shortly before the roof is ready. It may even happen that, particularly in single-lap tiling, the tiles for part of the roof have to be purposely made. Figs. 9 and 10 show a roof, circular on plan, to be covered with hand-made pantiles: on each slope there have to be the same number of tiles at the eave as at the ridge. Hence, on the outer slope the pantiles have to be wider at the tail than at the head, and vice versa on the inner slope. Special moulds have had to be made for each course—sixteen on each slope—and the period required for delivery is ten to twelve weeks. In Fig. 10 the outer slope has been completely felted and battened, the felt, it should be noted, being carried right over the ridge. The inner slope has been partly felted and battened.

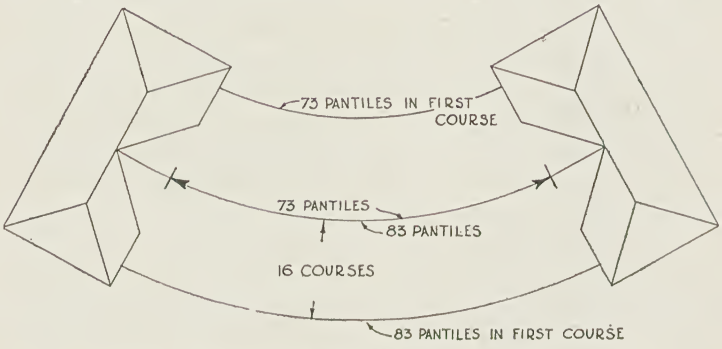


Fig. 9.—PLAN OF ROOF SHOWN IN FIG. 10

PART IV.—CONCRETE TILES

THERE can now be no doubt that concrete tiles have come to stay. In their early days they were unreliable as to both quality and colour, but the experimental stages are now past, and the concrete tile has taken its place beside the other and longer-established roofing materials. The quality of the best-known makes is high, the permeability is negligible, and the colours, although not yet permanent, do not bleach out and disappear entirely.

Kinds of Tile

Most concrete tiles are of the plain-tile pattern, but some firms make a form of interlocking tile that is, in appearance on the roof, similar to the Somerset No. 13 tile, while one firm, the Marley Tile Company, manufactures concrete single-lap tile of the Double Roman, Reynardo, pantile, and Spanish patterns.

Method of Manufacture

Nearly all concrete plain tiles are now manufactured by machine processes. The mixture of cement, sand, and body colour is fed from a hopper into one end of the tile machine: it falls on to the tile pallets, which move, with their load of mortar, under rollers, from which the concrete emerges as a continuous ribbon twice the width of a tile and of the correct thickness. The pallets and mortar move on intermittently and, at each stop, holes are formed, and a guillotine divides the ribbon into lengths, each equal to the length of a tile. A circular knife, rotating in the direction of the length of the

Fig. 10.—ROOF, CIRCULAR ON PLAN, TO BE COVERED WITH PURPOSE-MADE PANTILES

As will be seen, the outer slope has been completely felted and battened, the felt being carried right over the ridge. The inner slope has been partly felted and battened. (*Architects: Harold Williams & Partners, Croydon.*)

machine, separates the two tiles on each pallet. As the pallets and tiles move still farther along the machine, the surface colour is dropped from a sieve. The pallets, with their completed tiles, are taken off when they arrive at the end of their journey through the machine, placed on trolleys, and left under cover for approximately twenty-four hours. The tiles are then hard enough for depalleting to be done: they are knocked off the pallets, dipped in a solution which helps to render the colour permanent, and stacked in the open to mature. An average period for maturing, or hardening, is three weeks, but the time taken depends largely upon the weather. Such is an outline of the processes of manufacture.

The Double Roman and large tiles other than the ordinary interlocking have to be hand-moulded, but the general process is similar.

Colour

A certain amount of colour, usually oxide of iron or manganese, is added to the cement and sand in the mortar mixer: this is the body colour, and its purpose is to colour the inside of the tile, so that when cut or chipped the exposed surface shall be reasonably similar to that of the ordinary surface of the tile.

The surfacing colours are usually mixed with sand, in some cases burnt sand, to give the tile a sand face. The ordinary black, brown, and red colours are relatively cheap, but greens, marigolds, and similar colours are expensive, and for tiles of these shades an extra charge is nearly always made.

Modern Practice

The methods of application of concrete tiles are the same as those described for clay tiling: the concrete tile has, in fact, been made directly in imitation of the clay tile. The usual fittings—ridges, hips, valleys, angle tiles—are all of the same patterns as those used with clay tiles. Modern methods of application of clay tiles are dealt with on pages 209 to 224 of Vol. II.

PITCHED-ROOF COVERINGS

PART V.—ASBESTOS-CEMENT

ASBESTOS-CEMENT is made from Portland cement and asbestos, the latter being a mineral fibre found in veins in altered volcanic rocks in Canada, South Africa, Russia, and Cyprus. Asbestos is of two kinds: white, which is the ordinary commercial quality, and blue, which is used where great resistance to acids is required. In effect, asbestos-cement is a non-permeable, strong, fire-resisting, durable concrete, composed of asbestos-fibre and cement: the asbestos fibre, unlike most aggregates, adds to the strength of the cement.

The fineness and fibrous character of the asbestos render asbestos-cement easily moulded into very thin sheets of large size, making it eminently suitable for roofing slates, tiles, and corrugated and flat sheets. Of late years, also, the asbestos-cement manufacturers have challenged the makers of cast-iron goods by producing rain-water pipes, gutters, rain-water heads; imitation oak-panelling, draining-boards, decorated bath panels, sinks, and louvres are others among the many uses to which this amazing material is put.

Roofing Materials

The standard forms of asbestos-cement roofing materials are:—
Diagonal or diamond-pattern slates 15¾ in. by 15¾ in.
Straight-cover slates.
Small-section corrugated sheets.
Large-section corrugated sheets.
Angular-section corrugated sheets.
Pan tiles.

The dimensions and specifications of each of these types have lately been standardised by the British Standards Institution in *Specification No.* 690–1936, *Asbestos-cement Sheets and Unreinforced Flat Sheets and Corrugated Sheets.*

Diagonal-pattern Slates

Asbestos-cement as a roofing material was first known in this form. Its appearance on the roof and method of fixing are shown in Fig. 1, where also the terms used in connection with diagonal slating are illustrated. It should be noted that the lap is the amount by which one slate overlaps the ones beneath, measured at right angles to the top edge of

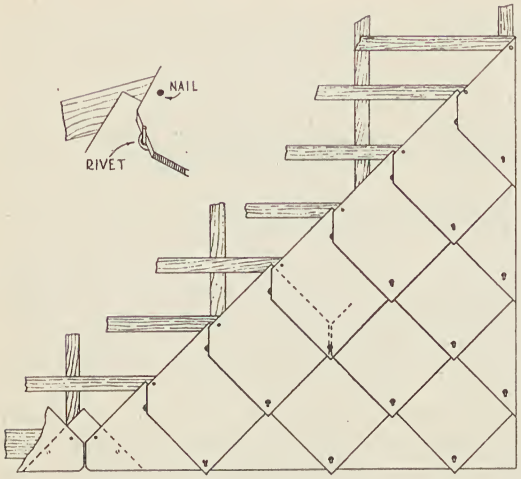


Fig. 1.—DIAGONAL-PATTERN ASBESTOS-CEMENT SLATES, 15¾ IN. BY 15¾ IN.

the slate that is covered.

The slates have to be specially holed by the makers to give the desired lap—2¾, 3, 3½, or 4 in. Each slate is secured with one copper disk rivet and two slate nails; copper slate nails are recommended, particularly in acid-laden atmospheres. The slates may be laid on battens or close boards. If the latter method is adopted, care is necessary in the coursing of the slates: true lines and uniform lap are essential to the avoidance of leaks.

A variation of the diagonal pattern is the honeycomb-pattern slate, Fig. 2, in which the "drop-point" is eliminated. The method of fixing is similar to that of diagonal-pattern slates, but the honeycomb type is made only for 2¾-in. and 3½-in. laps.

Technical data for these and all other asbestos-cement materials are given in detail by the manufacturers, and the figures given in these pages have been taken from the catalogues of Messrs. Turner's Asbestos Co. Ltd., Asbestos House, Southwark St., S.E.1, and the Universal Asbestos Manufacturing Co. Ltd., 43–46 Southampton Buildings, Chancery Lane, W.C.2.

Other large makers are The Atlas Stone Co. Ltd., 15 Victoria Street,

TECHNICAL DATA FOR 15¾-IN. BY 15¾-IN. DIAGONAL AND HONEYCOMB SLATING

Method of Laying	*Lap in In.*	*No. of Slates per Square*	*Batten Gauge in In.*	*Feet of Battens per Square*	*Weight of Slates per Square in Lb.*
Honeycomb .	2¾	86	8⅛	149	224
„ .	3½	99	7⅜	164	257
Diamond . .	2¾	86	8⅞	136	250
„ . .	3	89	8½	142	261
„ . .	3½	96	8¼	146	282
„ . .	4	105	7⅞	158	308

These figures are net, and include no allowance for waste. The weights vary slightly as between different makes.

Westminster, S.W.1, makers of "Atlas" products; and the Cellactite & British Uralite Ltd., Higham, Rochester.

Messrs. Turners are the manufacturers of "Poilite" diagonal, honeycomb, and straight-cover slates and pan tiles; "Everite" corrugated sheets, rain-water goods, etc., and of Turner's Trafford Tiling, or "T.T.T." as it is popularly called.

The Universal Asbestos Manufacturing Co. are the makers of "Handcraft" corrugated sheets; slates of all three of the types mentioned above; pan tiles; "Watford" Handcraft tiles, and other materials.

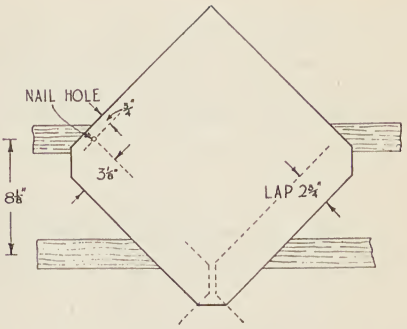


Fig. 2.—HONEYCOMB-PATTERN ASBESTOS-CEMENT SLATE, 15¾ IN. BY 15¾ IN.

Showing dimensions required by British Standard Specification No. 690–1936.

The roof pitches and their respective recommended minimum laps are as under :—

Pitch of Roof	*Minimum Lap*
40°	2¾ in.
35°	3 in.
30°	3½ in.
25°	4 in.

Straight-cover Slates

These are made in sizes 24 in. by 12 in.; 20 in. by 10 in.; 15¾ in. by 7⅞ in.; and 11¾ in. by 5⅞ in. They are laid in the same way as ordinary, natural slates, with the addition of one copper disk rivet near the tail of each slate, except in the case of the 11¾-in. by 5⅞-in. slate, which does not need a rivet. The slates are holed by the makers to give the correct lap.

TECHNICAL DATA

Size of Slate in In.	*Lap in In.*	*No. of Slates per Square*	*Spacing of Battens in In.*	*Linear Feet of Battens per Square*	*Weight of Slates per Square in Lb.*
24 by 12 . .	3	115	10½	114	398
24 by 12 . .	4	121	10	119	418
20 by 10 . .	3	170	8½	141	423
15¾ by 7⅞ . .	3	289	6⅜	189	404
11¾ by 5⅞ . .	2¾	519	4⅝	260	422

These figures are net, and include no allowance for waste. The weights vary slightly as between different makes.

Corrugated Sheets

Two kinds of corrugated sheets are manufactured—the small section and the large. Sheets produced by any one maker are not necessarily identical in all respects with those made by any other firm, but the information given below may be taken as fairly representative of the products of all firms.

The small, or standard, section corrugated sheet is stocked in 4-ft. to 10-ft. sheets, in lengths which are multiples of 6 in. The standard width is 30 in., the pitch of corrugations is $2\frac{7}{8}$ in., the over-all depth of corrugations is $2\frac{7}{8}$ in., the reputed thickness of the sheets is $\frac{1}{4}$ in.

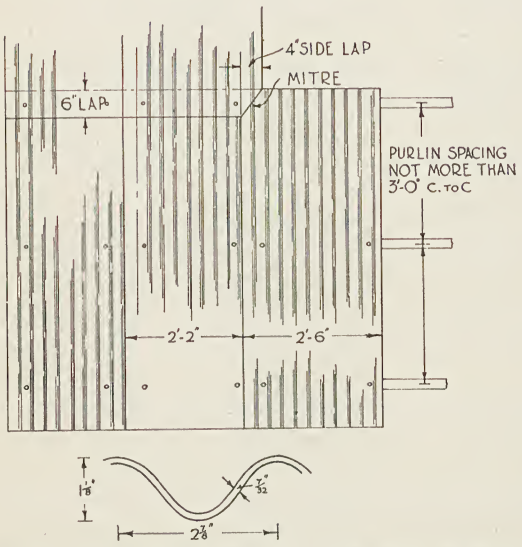


Fig. 3.—STANDARD-SECTION ASBESTOS-CEMENT CORRUGATED SHEETS FIXED TO WOOD PURLINS

Dimensions required by Specification No. 690–1936.

The end lap recommended for pitches down to about 30° is 6 in. For lower pitches, or in very exposed positions, the end lap should be increased or sealed with mastic or other suitable material. With a 6-in. lap and a side lap of $1\frac{1}{2}$ corrugations, the actual cover of a 9-ft. sheet is 8 ft. 6 in. by 2 ft. $1\frac{1}{2}$ in. The weight of 100 sq. ft. as laid is 270 lb. to 330 lb., according to the make and size of sheet. (The larger the sheets, the smaller the area that is covered twice.)

Fixing Corrugated Sheets

Fig. 3 shows in plan the method of fixing to wood purlins. Three-inch by $\frac{1}{4}$-in. galvanised iron screws, with lead cupped and fibre washers, are used, and it is important that the side laps should not be bolted together ; nor should the sheets be fixed more tightly than is necessary to attach them securely. The purlin spacing should not exceed 3 ft. Detailed instructions for fixing are issued by each manufacturer.

For fixing to iron purlins, galvanised hook bolts are supplied by the makers.

The large-section corrugated sheet, of which the Everite " Big-Six " and Handcraft " Super-Six " are typical examples, differs from the standard sheet in that it has larger corrugations and is slightly thicker. It is stocked in 4-ft. to 10-ft. lengths, in lengths which are multiples of 6 in. The width varies between 40 in. and 43 in., the pitch of corrugations

is $5\frac{3}{4}$ in., and the depth 2 in. Purlins may be spaced up to 4 ft. 6 in., as compared with the maximum of 3 ft. with standard sheets. The weight per square as laid varies between 310 lb. and 350 lb. The general fixing details are as for standard sheets, but the makers' instructions must in all cases be strictly followed.

Angular-section Corrugated Sheets

Angular-section corrugated sheets were originally designed to provide a rather better-looking roof than is given by the ordinary corrugated sheet. A typical form is illustrated in Fig. 4, but the sheets made by various makers differ in details. Fig. 4 gives the dimensions for an angular-section corrugated sheet as demanded by the British standard specification, a tolerance of one-quarter of 1 per cent. being allowed.

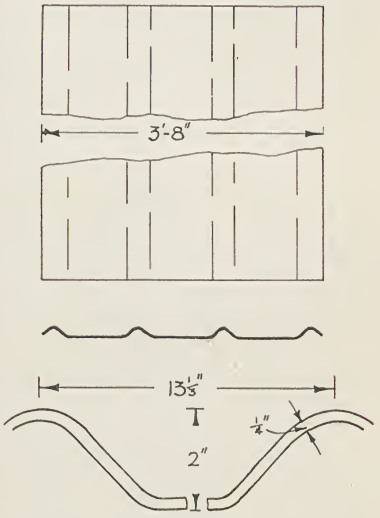


Fig. 4.—TYPICAL FORM OF ANGULAR-SECTION CORRUGATED ASBESTOS-CEMENT SHEET

Pan Tiles

The asbestos-cement pan tile has been designed on the lines of the English pattern of clay pan tiles. It has certain advantages over the latter: it is lighter in weight; more regular in shape, and therefore fits more closely on the roof; and it can be laid on pitches down to about 40° without felt or boarding. In one respect it is definitely inferior to the clay pan tile: the excessive thinness of the material robs it of much of the architectural beauty it might otherwise possess. This is, indeed, an objection to most forms of asbestos-cement roofing. Technical data are as follows:—*Size*: $13\frac{1}{2}$ in. by 16 in. *Cover*: 104–110 tiles per square. *Weight per Square as laid*: 330–370 lb. *Spacing of Battens*: $11\frac{3}{4}$–12 in.

There is no standard size of asbestos-cement pan tile. Each tile is held securely by two $1\frac{1}{2}$-in. or 2-in. galvanised nails.

A very wide range of fittings is stocked by most makers, including the following for the materials mentioned:—*Diagonal, Honeycomb, and Straight-cover Slates.*—Half-round ridge. Adjustable plain angular and plain angular ridges.

Corrugated and Angular-section Sheets.—Roof lights. Louvres. Finials. Barge boards. Valley tiles. Eaves filler pieces. Apron pieces. Two-piece adjustable close-fitting ridge. Corner pieces for angles in vertical sheeting.

THE CLERK OF WORKS

PART I.—QUALIFICATIONS REQUIRED, DUTIES AND CONDITIONS OF SERVICE

THERE are three distinct classes of clerks of works, whose fields of activity, specific duties, and conditions of service vary, but in nearly all cases they are occupied in carrying out the instructions of a superior officer.

The three broad groups are:—

(1) Clerks of works employed on new buildings;

(2) Those supervising the maintenance of, and additions to, establishments such as cathedrals, hospitals, university colleges, public schools, Government and municipal buildings varying in size from the Houses of Parliament to small housing estates, and large commercial and industrial offices and works; and

(3) The estate clerk of works, whose duties resemble those of the second class in many respects, but also demand considerable knowledge of agricultural life and woodlands.

One other class of supervisor is the military foreman of works or clerk of works engaged on establishments connected with the armed forces of the Crown. Usually he is a non-commissioned officer of the Royal Engineers, who has passed through the School of Military Engineering at Chatham, but a proportion, particularly on extensive new works in this country, are civilians.

Qualifications Required

The general qualifications are similar for all grades, in that each must have an extensive knowledge of building materials, constructional principles, and practical methods of application; he must have had sufficient education to be able to make works calculations and write intelligible letters and reports; and he must be of reliable character, and loyal to his employers and the architects and others who give him instructions.

He is a supervisor over whom there can be no direct supervision by his superiors, and the people with whom he is in daily association often have interests to serve that are not his.

Differences in Conditions of Work in Three Principal Grades

Beyond these general qualifications there are differences in the conditions of work in the three principal grades; suitability for a particular post, in either of them, depends largely on temperament.

For example, the estate clerk of works should be bred in and fond of the conditions of country life ; the clerk of works employed on the maintenance of and additions to establishments must be able to fit in a general administrative system, and have the tact and patience that are necessary, if constant friction is to be avoided, when meeting and dealing with the same people week by week and year by year.

The clerk of works engaged on new buildings must be prepared to put up with a lot of hurry, bustle, and controversy, and to accept the uncertainty of employment that is almost inevitable. As he is paid by the building owner, his services are not likely to be required after the building is completed, and the architect he is under may or may not have another job for him. The following details are principally concerned with the clerk of works employed on new buildings, who goes from job to job, but some notes on the other grades will be given first.

The Estate Clerk of Works—

As a result of the break-up of large country estates, the openings for clerks of works on them are much fewer now than they were at the beginning of this century. The big houses have been demolished, and the trees felled in the parks, but their influences remain. The well-built farmhouses, with their outbuildings, neat, orderly cottages, strong boundary walls and gateways, and firm, shapely by-roads, drives, footpaths, and footbridges, are evidence of the skill and care of the estate clerk of works.

—and His Duties

Usually he employs some direct labour, allocates its work, obtains the materials, engages the men, and pays the wages. He has to be familiar with all the district sources of materials, and the cost, design, construction, and repair of houses for farm animals, field produce, machinery, and implements ; with silos, gates, fences, roads, and paths, wells and pumps, land drainage and culverts, sewage-disposal systems, and the improvisations that are often required to meet local conditions and requirements.

In addition to a sound knowledge of the traditional building trades, the estate clerk of works has to be acquainted with the more modern innovations connected with heating, water supply, and electrical services, and the many specialist articles that add to the comfort, convenience, adornment, safety, and durability of dwellings.

The openings for employment in this occupation are not many for those unconnected with its particular circumstances. A house usually accompanies the salary, and the estate clerk of works has a status in his district that the town dweller does not usually obtain. As long as the estate on which he is employed continues to exist as a self-contained unit, his position is as secure as that of any clerk of works—much more so than most, and his contact with his employers is of a more intimate kind.

Clerks of Works on Establishments—

The largest employers of clerks of works on the maintenance of establishments are H.M. Office of Works and the London County Council. On county councils outside London the number has increased during recent years, on account of the increase in the number of schools and the transference of poor-law institutions and hospitals to them from boards of guardians. Provincial city councils have one or more clerks of works looking after the upkeep of their buildings.

—and Their Duties

Particulars of qualifications required, age, salary, and conditions of employment can usually be obtained on application to the appropriate authorities, and, although there are cases, sometimes, where vacancies are filled through inside influence, qualified men who desire this type of employment will sooner or later get it. Pay depends on several circumstances: from £300 to £350 and upwards in the larger centres, and lower in country areas; expenses for travelling on the employing authority's business, an annual holiday, and pay in whole or part during periods of sickness.

" Permanent " and " Temporary " Staff

There is also a distinction between the " permanent " and " temporary " staff, the former being entitled to a pension or superannuation allowance of a value that is conditioned by length of service. While, for ordinary work, the entrance age of the pensioned man is comparatively young, between 30 and 40, exception is made where experience and specialised knowledge are needed. For the " temporary " men there is no age limit if the applicant is fit enough to do his work, but, obviously, there is no guarantee of continuous employment.

Cathedral Clerks of Works

Cathedral clerks of works are in a separate category; the buildings under their care are national inheritances and not merely utilitarian structures that, sooner or later, will be out of date and demolished. A knowledge of the architecture and building of the past, its meaning and methods, and a feeling of trusteeship are essential: it is far from being anyone's job. Nearly always the cathedral clerk of works has been a stonemason; the pay is good, and the post a pleasant one for the right man, except, perhaps, when structural failure threatens the building.

Hospital Clerk of Works

The hospital clerk of works has to be a resourceful diplomat as well as a technician, and able to absorb a considerable amount of specialised knowledge. The engineering plant—heating, ventilating, lighting, and power—is usually extensive, and, although he will have the assistance of

practical engineers and electricians, he must understand the ordinary causes of failure and their remedy. Hours are irregular and emergency calls not infrequent.

Usually there is a direct-labour staff to superintend, and some clerical assistance available. The posts are permanent and pensioned; pay varies, in large hospitals from £400 to £500.

Commercial and Industrial Buildings

On commercial and industrial buildings the positions of establishment clerks of works differ so greatly that no general statement can be made. Often he has been the foreman in charge of the direct-labour staff, and is familiar with the firm's requirements and the layout of their premises. On the whole, it is not such a secure post as the others mentioned.

The advantages attaching to the position of an establishment clerk of works are security of tenure and usually, although not always, a pension; frequent contact with others in the same service whose interests are identical with his; holidays, and freedom from the irksome task of having to work against too short a time limit.

The disadvantages are an element of monotony in the daily routine, less independence and freedom of movement, and the circumscribing effects of detachment from the main stream of building work. On the economic side there is probably not much in it except during periods of scarcity of new work. Then the free lance may have longer periods of unemployment than are good for any man, while the establishment clerk of works continues at his job.

The Clerk of Works on New Buildings

The clerk of works on new buildings is usually a man who has been a skilled craftsman and, later, a general foreman. There are exceptions, particularly with regard to the foreman. Formerly the sequence was skilled craftsman, trade foreman, general foreman, and ultimately clerk of works, but during recent years the status, income, and permanence of employment of the general foreman have been improved to a degree that has removed the "ultimately." The position of the clerk of works does not necessarily present any special attractions.

On the whole it is an advantage to have been a skilled craftsman, a carpenter, bricklayer, stonemason, etc., because of the intimate acquaintance with materials and processes and the inside of the world of building that is obtained thereby. But a highly skilled operative is not necessarily a good supervisor; he may be quite an indifferent one—a one-track man who is lost when away from his own speciality.

Further, an exhaustive knowledge of, say, masonry, applies to one subject alone and its few contacts with other trades. The difficulty is to become acquainted sufficiently with all sorts of subjects—masonry, plumbing, concrete, drainage, heating and lighting, asphalting, and the

many other parts—to be able to see them and recognise right from wrong and the innumerable grades of rightness and wrongness. That is why, on his first job, the clerk of works who has been a general foreman has an advantage over most others. Some aspect of nearly all problems he has met with in his former occupation.

Organisation is the Key to Successful Building

Earlier it was regarded as desirable that a clerk of works should have been a foreman, because he knew the tricks of the trade—and he often did. But in this respect there has been a great change, apart from the fact that a considerable proportion of the items in a contract may be executed by sub-contractors—sometimes as high a proportion as two-thirds. It is recognised that organisation, particularly of labour, is the key to successful building, and that attempting to evade the requirements of a contract is not worth while. Standardisation has done much to remove the temptation to substitute inferior materials.

How to Obtain a Working Knowledge of the Necessary Trades

The difficulty referred to above, of obtaining, in addition to operative experience, a working knowledge of a wide variety of trades and their materials, mechanisms, and apparatus, which presents an obstacle to the young man who desires to become a clerk of works, can be partly surmounted by taking advantage of the facilities offered at technical schools. In most large towns, classes are held on subjects connected with building, and help can also be obtained by reading reliable books on building subjects and taking correspondence courses. The expense is comparatively small, and the ambitious must be prepared to sacrifice both time and money in pursuing their object.

It is the background of knowledge thus obtained, added to personal experience on works in progress, which will make intelligible the complications of modern building work when they are read of and seen during the period which must elapse between the end of attendance at schools and the beginning of responsibility as a supervisor.

It must be remembered that in the ordinary course of events a man will not be appointed as a clerk of works until he reaches the neighbourhood of 30 at the least. There are exceptions here, as in all other affairs, but the statement can be accepted as one of fact. On large works, particularly where completion in a short time is important, few clerks of works will be found who have not reached at least 40. Incidentally the limit at the other end of the scale is higher than in most occupations ; not infrequently men of over 70, who are able to meet the physical demands of the occupation, are appointed, and in at least two instances 77 has been reached. Both, however, were exceptional men—Thomas Simpson and Alfred Fincham. The limiting lower age for candidates set by the

Incorporated Clerks of Works Association, in Part II of their recently established examination, is 28.

What a Clerk of Works Should Know

At the technical schools it is advisable to take courses in building construction in all its phases, builders' quantities, applied geometry and mathematics, mechanics, and the chemistry and physics of building materials. In addition, of course, there should be the ability to write English in an understandable manner, and to draw. Tee-square drawing of details, as distinct from design, is essential and a common accomplishment. What is not so easily done, nor so frequently found among supervisors, is the ability to make perspective sketches of details approximately to scale. It is a most useful faculty, and well worth practising.

General Scientific Knowledge Is Advisable—

The advantage of obtaining enough general scientific knowledge to be able to appreciate the inner structure of things, so that the mind's eye can see what is happening, as a skilled motor mechanic can "see" what is happening when he listens to the sounds of a bonneted car, cannot be over-estimated. What actually happens to concrete, mortars, and plasters when they set and harden, and to paint when it "dries"; the internal changes in metals when subjected to changes of temperature, and in wood when moisture enters and leaves, and the effect of stresses on structural parts, can be visualised much more clearly by using scientific knowledge than by direct observation.

—but Expert Knowledge Is Not Essential

The clerk of works cannot hope to become expert in such matters; even if he absorbs facts readily at school he will forget a lot of them when the time arrives for direct application, but the general principles will remain and always be helpful. Testing cement and steel for reinforced concrete must be done by a specialist in a laboratory, if reliable results are to be obtained, and this applies to most materials where scientific accuracy is necessary.

The Standard of Accuracy

The building standard of accuracy is not that of the scientist, nor, for that matter, of the mechanical engineer, and the clerk of works who seeks it on the job handicaps himself unnecessarily. But his contact, over many years, with materials and processes, added to school- or book-acquired information, will, when associated with the mental faculty which is known as being "practical," bring an intuitive judgment to bear on the problems of daily work that can and must be trusted. There is one reservation: it must not be a judgment biased by likes or dislikes of individuals.

Confidence usually develops as time passes ; it is required in any post of responsibility, and the acquisition of knowledge lying outside the boundaries of personal experience is one way of increasing it. The point that every advantage should be taken of educational facilities is stressed because there still exists, although to a lesser degree then formerly, a tendency to deprecate it because it is not " practical." As a matter of fact quite a lot of useless theorising is done because of the lack of the very kind of knowledge that is deprecated.

When a Clerk of Works Should Advise but Not Instruct

It is inadvisable for a clerk of works to use such knowledge as he may have gleaned if by doing so he alters mechanical and electrical engineering schemes, and thereby removes from sub-contractors the responsibility for efficient results, and the same point applies to materials where a guarantee of durability has been entered into. He may suspect, or know, that wrong methods are being adopted, and must take action ; but instructions to alter fundamental parts of schemes should be made by his superior, the architect or the consulting engineer.

That the clerk of works must be loyal to his employers and the architect or engineer over him need not be stressed ; he will not experience much difficulty in that respect. That he must be honest is an obvious fact. But that he must always be resourceful, ready with a decision, friendly and courteous to everyone, never lose his temper, and be at all times a model of tactfulness and propriety, is asking a bit too much. He can hope to be part of these things all the time and all of some of them occasionally.

Relations with the General Foreman

He comes into contact, close contact often, with all sorts of people : his employers, the professional men and their assistants from whom he receives instructions, the builders, the officials of public corporations, representatives of specialist firms, all the grades of operatives working on the job, and the general foreman. With the latter he is in contact nearly all the time. Where there is general agreement, each recognising the status and duties of the other, the job runs smoothly. Where there is not, the situation is unpleasant, to say the least, and sometimes it can be particularly unpleasant, when opposite temperaments clash. When that happens the clerk of works must make the best he can of an uncomfortable situation ; usually the less that is said the better for both. In any case it is unwise to hand on complaints to the architect unless something is radically wrong ; there is always the possibility that the general foreman may be the better man.

An element of controversy between the two men can be taken for granted : whether certain materials are suitable, enough men being employed, the setting out and other work accurate, and so on. On rush

jobs the foreman may have to employ on finishings men who are incompetent and their work on the border line, a frequent source of annoyance. The clerk of works can only balance values, time against quality, and act accordingly, unless he has reason to suppose that scamping is encouraged. He must get the best job he can under the circumstances and, if the foreman is doing the best *he* can, assist him as far as is possible.

The occupation of a clerk of works is one in which harmonious relations with other decent persons is as important a factor as an intimate knowledge of the inanimate things that go to make up a building. He must be an acceptable individual as well as a competent technician.

How a Post Is Obtained

For most appointments on large buildings, previous experience as a clerk of works or as a general foreman is nearly always necessary. Some posts are advertised, particularly when the work is to be done for a public authority ; others are filled by societies such as the Incorporated Clerks of Works Association, who keep a register of disengaged members ; and many are filled privately through inquiries by architects or surveyors from other members of their professions, or from clerks of works known to them. In all such cases references of previous work done and of character are required, together with particulars of age, trade, etc. Confirmation of references is usually obtained when the appointment of a particular man is contemplated.

No advantage is gained by writing long letters with a publicity flavour in them ; all that is necessary is a clear statement of qualifications and experience, salary required, and other relevant items, which both conveys information and provides evidence of ability to write intelligible English.

It is on the smaller jobs, or those which, while not being small, are comparatively simple in character, that the younger and less experienced men will have the best chance of an appointment. Generally speaking there is no direct road to promotion on the operative side of the building industry, with a rising scale of salary and higher appointments in due course ; taking the first step may require some years to perform if the help of relatives and friends is not available.

As many more foremen than clerks of works are employed it is through that channel that a young man has the best prospects of becoming a building supervisor. Builders have lots of small jobs on which a foreman is needed, and satisfactory performance on the smaller ones opens the way to wider opportunities. Either by writing or by personal application the suitable man will sooner or later obtain a foreman's job, and if he then desires to become a clerk of works he will be so much nearer his goal.

Evidence from previous, or existing, employers is necessary, obviously, and a general testimonial from someone in a public position is helpful. The possession of certificates gained in recognised examinations, held by external authorities, may be a deciding factor, particularly in the case

of public authorities. Answering advertisements appearing in building-trade publications, and obtaining and filling in forms supplied on application by Government departments and county councils, are the more likely ways of obtaining a first appointment. The occupation of a clerk of works is not, when trade is thriving, an overcrowded one, and subject to the conditions mentioned earlier, that the applicant must be acceptable both as a person and as a technician, an appointment will be forthcoming sooner or later.

The Clerk of Works' Salary

Salaries vary considerably. Provincial public authorities often offer pay that is entirely inadequate, and the man who has a job as a foreman will be better off by sticking to it than by accepting such appointments. On the larger buildings, both in London and in large cities and towns, salaries range from £8 8*s*. to £10 10*s*., with more in some instances. Out-of-pocket expenses for office requisites, postage, and other matters directly connected with the execution of the work, are paid by the employer and, in the case of clerks of works engaged on work distant from their homes, there is usually a mutual arrangement respecting personal travelling expenses. For distances 50 miles or so from London, the cost of a season ticket may be allowed, which will cover the expense of both business and personal journeys on the route. In other cases the allowance is for a monthly personal visit. Lodging allowance is usually added to the salary. One other point connected with personal payments should be made: the clerk of works will be well advised to take out his own accident policy.

Conditions of Employment

The clerk of works is, where the standard form of building contract is used, an inspector who has access to all works and materials connected with the contract. But in most circumstances he is more than that: an architect's technical assistant on the works is a fairly accurate definition of his position. Theoretically, his hours are those during which work is in progress, exclusive of overtime, but usually he starts later than the commencement of the working day and not infrequently stays after the last whistle has blown, it having been impossible to do the necessary office duties earlier.

There is no general rule, but the clerk of works' appointment is one of trust and he has to treat it as such. Where continuous overtime is being worked, say two hours or more a day, he has to stay, and can reasonably expect extra remuneration for doing so, unless overtime is taken into consideration when his salary is fixed. But it is unwise, to say the least, for him to act as one receiving a standard rate of pay for a standard period of hours. During part of his employment, particularly the early stages, he will have little to do; at other times he will be fully occupied, and the

amount of effort expended over the whole period of his employment is thus balanced.

He has to be very circumspect when dealing with employers, answering their questions and receiving their instructions. Sometimes he will be asked whether a particular alteration would not improve some part of the design, and he will almost certainly hear criticisms of the design. The best thing he can do is to know nothing about the one, and to forget the other. Instructions from the employer should be referred to the architect, unless there is an understanding that the clerk of works may, without reference, carry out additional items connected with internal equipment, such as shelving, ironmongery, and other conveniences.

Payment of salary is either weekly or by monthly cheque. If the latter, it is a convenient arrangement to send a monthly statement of salary, and any expenses that have been incurred in connection with the execution of the work, to the architect, who will initial and forward to his client for payment.

Equipment Required by the Clerk of Works

On taking up an appointment the clerk of works requires a few things that are his own property. Tee-square and drawing-board will be provided, but he should have his own drawing-instruments—a small, good set of compasses and two fairly large set-squares ; a four-fold 2-ft. rule is a necessity, and a two-fold 5-ft. rule is the usual wand of office. It impresses the employer, and is a more convenient instrument than the 5-ft. steel rule that curls up in a little iron box. A 100-ft. steel tape is a good investment ; it costs more than a 66-ft. one but is worth the additional outlay. With a little care the ordinary steel tape can be kept free from rust : stainless-steel tapes are apt to be brittle. Linen tapes are too unreliable for building use.

A Three-screw Dumpy Level Is a Useful Possession

Possession of a dumpy level is not essential. The builder will probably be willing to provide it, but to own one is a great advantage at most periods of the job, for the preliminary setting out, drains, paths, roads, and general internal work. An outlay of £14 is sufficient for a serviceable level, preferably a three-screw, that will be good enough for all ordinary purposes. It is not a difficult instrument to use ; a study of the general principles and some careful practice will enable the beginner to do all that is necessary on buildings. Field surveying over long distances is another matter.

A pair of gum boots, a waterproof that has passed its best days but is still proof, and a hat that will stand knocking about, complete the personal equipment. Whether an overall coat is worn is a matter of taste. It certainly protects clothes.

Accommodation Provided by the Builder

A clause in the specification will call for the provision, by the builder, of an office and lavatory, fuel, light, and attendance. Sometimes a telephone is included, and on large jobs there may be other services.

The Office Equipment

Where the site is restricted, as is the case where the whole area is built on and the office has to be put on a gantry or tucked away in a corner during the early stages of the work, it is necessarily small, 10 ft. to 12 ft. by 8 ft. Later, as the building grows and drawings accumulate, a larger one is required and can be had. On a free site, with ample space surrounding the buildings, a sufficiently large office can be had at the commencement and retained until the completion of the work ; 16 ft. by 9 ft. or larger, as may be necessary. It should, of course, be sited to miss drain routes and other external works. A window along most of the length of one side is necessary, with a desk against it, about 3 ft. high and 2 ft. 6 in. wide, which will give space for the drawing-board, laying out drawings, etc.

Drawers under the desk for drawings, a small drawer to the right of the knee space for instruments and other small articles, short shelves at the end of the desk for files and papers, a rack for cancelled and miscellaneous drawings, and a shelf or two for samples, are the general fitments required, the size and quantity varying according to the nature of the job. Electric light can usually be had, and a small, slow-combustion stove on a slab, with some fireproof material at the back, is preferable to an electric fire or oil heater for warming, although not always convenient.

Attendance implies the provision of someone to do the chores in the office, prepare food and tea if required, run errands, and perform similar duties. An old naval man can be very useful at this sort of thing.

Stationery

The clerk of works will have to obtain some stationery ; he usually pays for it and is reimbursed by the employer on presenting receipted bills. A foolscap book is the most convenient form of diary. For letters, a duplicate writing-book is better than loose sheets, the job address—" Clerk of Works Office," and name of building—and the telephone number being printed at the top, and the pages numbered. Small, stiff-covered note-books, a dimensions book, perhaps a surveyor's levelling book, and a cheap note-book for stamp entries, are further requirements, together with such items as detail paper for drawing, foolscap, envelopes, drawing-pins, cheap letter-files, paper clips, rubber bands, ink, and pencils.

PART II.—THE CLERK OF WORKS' STATE OF WORK AND PROGRESS REPORTS AND RECORDS

WEEKLY report sheets will probably be provided by the architect. They vary in arrangement ; some, for instance, have columns for the number of men in the different occupations—labourers, scaffolders, plant operators, bricklayers, etc.—employed each day ; on other sheets one set of numbers only is required, which assumes little alteration during the week. The former is preferable ; not much extra work is involved in filling in the daily numbers, and the complete set of figures serves as a useful chart, particularly when there are appreciable fluctuations between Monday and Saturday.

Usually the report items include number of men employed, weather, names of visitors, numbers of drawings received and names of drawings required, and a description of the state of works at the end of the week.

Some have columns for materials delivered on the site, information which may be useful but entails a lot of work in compilation, and is of little value when the materials are being consumed quickly. When specially made or unusual articles are in question, and their delay can hold up work, the architect is able to put pressure on the supplying firms if the clerk of works' materials statement shows that delivery is slow. But for ordinary things—cement, sand, ballast, shingle, common bricks—a return of these is useful only if the status of the builder is uncertain.

The numbers of men employed will be supplied by the foreman or time-keeper, and an occasional check can be made. Sometimes sub-contractors' numbers vary appreciably ; when the firms have been appointed by the architect it is advisable to instruct their charge hands to report numbers daily to the time-keeper. On small jobs this is not necessary.

Weather Descriptions

These need not be detailed. Rain or frost, and time lost because of either, should be so described ; most ordinary weather, when work is not delayed, is, for building purposes, "fine." Greater accuracy may be desirable in winter when concreting is being done. A maximum and minimum thermometer should be used, and its night, 8.30 a.m., and 3 p.m. readings recorded, but not necessarily entered on the report sheet.

"State of Works" Descriptions

These descriptions differ from diary entries of work done in that they describe the condition of the job at the end of the week. The diary entry records that the west wall on the second floor is being raised—the work being done ; the report states that it is at window-cill level—the stage that has been reached on Friday or Saturday.

How to Classify the Various Items

Classification of items is necessary if the architect is to obtain from the report a clear view of the partly built structure, and inserting sub-headings for floors or trades is as useful a method as any other. Where there are several blocks of buildings, or wings of a single large building, a double classification is necessary—the block or wing and then its parts.

Excavations

Excavations can be recorded as being so much below ground, or ground-floor, level ; foundation concrete located by its position (" foundations of N. and E. external walls concreted ").

Walls and Stonework

Walls can be given as heights above floor levels ; concrete floors by the names of the rooms over ; stonework either as walls or in special items (" main entrance stonework at lintel level ").

Roofs and Flats

Roofs and flats can be indicated by positions and stages of construction (" rafters fixed at E. end " : " flat over kitchen centered ") ; pointing, as a percentage of the total area.

Plastering, Floor Covering, etc.

Percentages are useful in connection with plastering, floor coverings, and similar surface finishes ; with a little practice they can be estimated fairly closely. Complete accuracy is unnecessary, and too optimistic an estimate of progress is unwise.

Steel Framing

Steel framing can be described as having reached a particular stage, the stancheon and beam numbers on the drawings being used to describe it ; or the percentage method can be employed.

Recording the Progress of Pipe Work

The progress of pipe work—plumbing, heating, water supplies, and electrical services—can be given at intervals : obtaining detailed particulars of these is a laborious task, and a general statement of the situation at intervals of, say, three weeks, is usually sufficient.

Panelling and Other Joinery Finishings

The condition of a large, panelled room is an item by itself, but for doors, skirtings, and other joinery finishings, that consist of many comparatively small scattered items, a percentage value is the most convenient. The number of items, as work approaches completion, is so many that the clerk of works can only use his own discretion as to what

should go into the weekly report and what be omitted. In one form or another, in reports, diary, or note-books, there should be a record of the salient particulars of the job in progress.

The Clerk of Works' Diary—

Diaries should contain most of the statistical items included in the reports, together with particulars of the principal work done each day, instructions received from the architect, engineer, or surveyor, transactions with sub-contractors, and any items of importance concerning which information may subsequently be required.

—and How It Should Be Compiled

The clerk of works need not congest his diary by recording all the occasions when he raises objections to work done or materials supplied. The matter may be trivial and easily put right, or it may be important. It is one thing to object to an occasional load of loamy sand, and quite another to object to a large consignment of, say, London stock bricks. The former need not be written up, but the latter should be.

In a foolscap diary the left-hand margin can be used for general terms—such as " Visitors " in the margin, and their names on the other side of it. In the same way, the building divisions can be put in the margin—" foundations," " 2nd floor," " roof," and so on. Such specialist items as lifts, steel windows, marble floors, etc., can be separated from the building divisions and treated as special items. Walls and partitions, including foundations, are described in relation to the points of the compass or adjoining rooms, and room names are best when describing floor construction and coverings, plastering and finishings. For external work, such as drain laying and path construction, points of the compass in relation to adjoining buildings are suitable.

There is no hard and fast rule with regard to diaries, and the clerk of works can use his own ingenuity in compiling them. The objective is to so record the state of works that he can subsequently give the date on which the larger parts of the work were being done, the plinth built, floor concreted, roof asphalted, partitions built, a room plastered, lift erection commenced, or a drain laid.

Entries that Are Unnecessary

Of many of the smaller things it is a waste of time to make entries. If he records when every sink waste was fixed, length of steel tubing put in, cornice run, door hung, skirting painted, or manhole concreted he will spend more time in his office than on the job, and no one will thank him for it. If the contract is a small one, and sufficient time is available, no harm is done by making entries of small items ; it may be good practice for busier work later on, and certainly helps to fix things in the memory, but it is not necessary.

Entries that Must Not Be Omitted

One type of entry is important—the date of commencement of work by sub-contractors, and the delivery of such items as boilers and other special plant. When disputes occur respecting delay they often resolve themselves into controversies as to relative responsibilities of the builder and the sub-contractors, each accusing the other of hindering progress. The evidence of the clerk of works' diary can be very valuable then. Actually he can do more than a little to obviate controversies by looking ahead, seeing that the sub-contractors are notified in ample time, and are given and give, at an early stage, full information and drawings respecting their work.

Keep a Note of All Important Statements

For diary entries of statements made at interviews, it is obvious that the important and the unimportant must be separated. That the wardrobe cupboards are " in hand " may mean anything ; that they will be delivered on Wednesday is a definite promise to be recorded. Architects' instructions must be entered in full ; often they are on comparatively minor details which the clerk of works must pass on as an order to the builders.

The Chit System

This he can do in his letter book by writing a chit to the foreman, which is accepted as being an order from the architect. Sometimes the latter confirms everything himself, and sends a variation order, but, if both architect and builder are willing to agree to it, the chit system between clerk of works and general foreman is a satisfactory method of dealing with small variations or additions.

On the whole, it is advisable to adopt a formal style of letter writing in which the necessary facts are clearly conveyed. A frequent request is that materials be delivered or work executed more rapidly. All firms receive a lot of that sort of thing and become hardened to it, so the phrase " very urgent " should be kept in reserve for matters that have actually reached that stage.

Sometimes a lengthy report on a special subject has to be made, a failure of plastering, for instance ; here it is particularly necessary to give exact information, and not to indulge in a diatribe against a person or persons. One other point is the desirability of following up telephone decisions, given or received, with a letter.

Dimensions and Descriptions of Work Done

The clerk of works will, at intervals, have to record, for the information of the quantity surveyor, dimensions and descriptions of work done. In foundations there are almost certain to be measurements required of additional or omitted excavating, concreting, timbering, etc. ; drainage is

another item that he may have to measure, and other constructions where work has been completed and hidden before the surveyor pays a visit to the job.

Records of ground and excavation levels not given on the original drawings are always useful, as are notes on general omissions and extras, and copies of any drawings that the clerk of works may have had to prepare.

On important buildings in or near towns the surveyor's visits will be fairly frequent ; on others he will not come so often, and will look to the clerk of works for information respecting hidden work and matters on which the builder may claim extras. The measurements should, of course, be entered in the manner adopted by surveyors, and be taken with and agreed to by the foreman, and initialled. Where the job is not large, and is a long way from his office, he may ask the clerk of works to send such particulars as will enable him to check the builder's applications for certificates—the state of works and quantities of materials on the site.

The Daywork Sheet

The daywork sheet, that bone of controversy, will put in an appearance on every kind of job except the very simplest ; sometimes they are few in number, and at other times there are hundreds of them. Some architects and surveyors require that they be presented by the builder at the end of the week during which the work described in them has been done, and this is the best method.

On buildings of the more complicated sort, containing a variety of engineering installations, where everything has to be done in a hurry, it is difficult not only to get the sheets but also for the clerk of works to attend to them and to keep notes of the time spent on daywork. Then there is usually an accumulation at the end of the contract which has to be examined and made available for the surveyors. It is the latter who decide whether a particular item should be priced at daywork rates, or measured, or regarded as an integral part of the builder's or sub-contractor's liability under the terms of the contract.

The clerk of works' signature implies that a certain piece of work has been done, so much time has been spent on it, and so much material used. A decision as to whether it should ultimately be paid for rests with the surveyor.

It helps the surveyor if full notes are put on the daywork sheets explaining the origin of and reason for items, with such references to letters and drawings as may be useful. Where, because of oversight or pressure of other work, no notes have been taken, and unquestionably the work has been done, the clerk of works has to use his judgment as to what is a fair time, but usually there will be a connecting link of some kind in his records that will help. When full notes are available no difficulty presents itself.

On buildings where the profit-on-cost system operates he signs the whole of the time sheets, and is able to devise an arrangement that will be practically watertight. Daily returns from the foreman of men employed, and a frequent check, are advisable. He will also have to sign lists of materials used. Delivery notes for these will be held by the foreman and at the disposal of the clerk of works ; usually it is possible to make a cross-check of materials by measuring particular bits of work done. On large profit-on-cost jobs it will, of course, be necessary to get the help of an assistant or assistants, but such cases are not frequent, and for them a special organisation is necessary.

Progress Charts

Time and progress charts are usually prepared by the builder, who obtains the agreement of the architect, engineer, and sub-contractors to his allocation of periods. The charts are set out on squared paper, vertical spaces being given to each week, and horizontal spaces to trades or other sub-divisions of the work. The length of a line, or pair of lines, drawn along a horizontal space from one vertical space to another, indicates graphically the time allowed for, say, plumbing. The beginning of the line is in a space which reference to the top of the sheet shows to be the week commencing May 4th, and if everything goes along according to programme the plumber commences his work then. The end of the line is at September 12th ; on that date the plumbing must be completed.

When Alterations and Additions have to be Completed Quickly

The clerk of works will find the system very useful when alterations and additions have to be completed quickly, such as during school holidays. It may be that the time allowed is too short, and completion practically impossible, particularly if wet weather intervenes. But he, in collaboration with the other people concerned, has to do the best he can, and preparing a progress chart is a far better method than trusting to day-by-day pressure.

In the horizontal divisions it is advisable to put stages of the work and not trades, as the latter are interlocked and do not follow the orderly sequence that obtains on new work. Demolition ; foundations ; work to 1st floor ; to 2nd floor ; to roof or alterations of the roof ; staircases ; fixing grounds, etc. ; plastering ; floor screeding ; plumbing ; floor laying ; joinery fixing ; decorating, and all the other items—periods are provisionally allotted to each according to the character of the work to be done. They will overlap, of course ; plumbing may be in progress before the roof work is reached, and so on. On the first draft the periods allotted to the various sections may not bring completion soon enough, and adjustments have to be made until an apparently practical scheme has developed itself. Then the foreman must be consulted, and he will probably discover that further adjustments are necessary, but the final result, even if in practice it is found to be rather faulty, will be of value to him as well

as to the clerk of works, and enable both to keep their heads at a time when, without the chart, they might lose them.

Drawers for Drawings

The number of drawings received may be anything from twenty or so, on small contracts, to many hundreds, and even thousands, on large ones ; their orderly disposal in the office is necessary so that reference can readily be made. If there are several plans, basement to 5th floor, for instance, the sheets are probably of the same size and can be fastened together with washered paper clips, or wood clamps, along the left-hand margin. Ready recognition of other drawings is facilitated if the description is written or printed with a thick pencil in the bottom right-hand corner. A collection in a drawer can be flipped over quickly, and the required one identified at a glance.

Most of the architect's drawings will be to either $\frac{1}{8}$-in. or $\frac{1}{2}$-in. scales, or full-size details ; a drawer or drawers for each class is advisable. Of the other drawings, those showing the steelwork and concrete will be the more numerous and should have their own drawer ; white or yellow pencils make legible marks on blue prints. For specialists' drawings that are few in number a convenient arrangement is to fold them once and write the sub-contractor's name on the back of the outer one.

Registering the Drawings so that they can be Referred to Easily

A register of all drawings received, their number and title, has to be kept, with a separate space for each sender. As far as is possible it is desirable that drawings be kept in the order of their numbers, 1 at the top and so on, but when frequent reference is required, and particularly when several have to be referred to at the same time, all relating to a particular piece of work, the numbers are apt to get mixed up. So much depends on the size and type of jobs, and the conditions prevailing at different stages, that only one hard and fast rule can be enforced—the drawings must be so registered and arranged that they can be referred to readily.

The several aspects of the " clerk " part of a clerk of work's occupation have been referred to at some length—reports, diary, correspondence, day-work records, progress charts, filing drawings, and other matters—because they are an integral part of his work. But there are many occasions, when he has to adapt the procedure to fit the one that is his immediate concern ; to test, check, and alter as experience dictates, and to spend such time in his office as is necessary, but not more. The remainder of these notes will deal with the " works " part of the occupation.

PART III.—NOTES ON PRACTICAL WORK—SETTING OUT, FOUNDATIONS, AND CONCRETE WORK

IN the notes on practical work which follow, it has been assumed that the reader is acquainted with customary building methods, terms, and job conditions. The intention is that they shall be of some assistance to the man who, while being far from a novice in the building industry, has only a limited knowledge of the duties of a clerk of works. The older and more experienced may be able to pick up useful hints, but they will be familiar with much of the information offered.

Setting Out

The builder is responsible for accuracy in the setting out of a building, with regard to both its position in relation to boundaries, and the placing and dimensions of walls, piers, and other parts. The foreman usually does it, and the clerk of works checks, or they may do it together. But, although the rectification of mistakes is the builder's liability, it is a reflection on the clerk of works' capacity if appreciable errors occur. Small differences of $\frac{1}{4}$ in. or so on large sites are common enough and matter little ; the larger errors, if undetected in time, will be a nuisance until the end of the job.

Working to Frontage Lines

On expensive town sites it is important that the correct frontage lines be adhered to without deviation ; they may be defined in relation to adjoining or opposite buildings, or the pavement kerb, and will be shown and dimensioned on the site plan. The district surveyor, building surveyor, or building inspector will insist that frontages are accurately placed. On large, open sites the line of reference may be the centre of a road or fence, the face of a fence, or even the centre of a hedge. Where it is rather ambiguous stakes should be driven in on the line of the assumed boundary, and agreement to its position obtained from the persons interested in the adjoining properties.

Where existing buildings adjoin the site, notes of their condition, including particulars and the exact location of cracks and other defects, will probably be made by the surveyors representing the interested parties. But it is advisable for both the clerk of works and the general foreman to make their own inspections before excavation commences, take such notes as appear to be advisable, and fix tell-tales. Copies of Party Wall Awards and the drawings relating to them will be supplied to both. Here, again, the liability is the builder's, but the clerk of works must do what he can to avoid subsequent disputes in which his employer may be involved.

Setting Out on Level and Falling Ground

On open, level ground, where the familiar method of fixing profiles can be adopted, setting out does not present any special problems. It is always worth while to have the profile boards whitened, and to mark the walls, footings, and foundation concrete positions on them with coloured pencils ; and also to drive the stakes in firmly so that they are not disturbed during excavating. When the profiles are marked, and the lines strung across them, the running distances between the intersections are checked for accuracy of length, and diagonally for accuracy of angles.

On inclined ground the matter is less straightforward, and care has to be taken that dimensions are measured horizontally and not parallel with the slope or slopes.

On a large site with an oblique fall, where foundations were of the post and beam type—concrete wall beams resting on short piers that had wide bases—the excavations consisted of a series of deep, square holes and shallow trenches. Profiles were fixed at appropriate heights, the positions of the walls set out on them, and wires stretched at definite levels along the centre line of the walls. The centres of the piers were located on the wire by tightly knotted pieces of string. Batten templates to the over-all sizes of the holes were made, with their centres clearly marked, and a plumb-line dropped from the point on the wire to the template centre. The template had, of course, to be kept square to the direction of the wall. The wires were also used to give the navvies preliminary depths ; they worked to a rod a little less in length than the distance from the wire to the finished excavation ; the final depth was obtained by using pegs and a dumpy level. Wires are more reliable than cords over long distances.

Setting Out in a Basement

On sites where setting out takes place in a basement excavation, overhead lines or wires are necessary. It is usually possible, where party walls of adjoining buildings bound the site, to register datum points and levels on them which remain in use until the foundations are completed. Often the building cannot be set out as a whole ; stancheon bases are being laid in one part while the excavation is proceeding elsewhere, and the use of the datum lines is essential. All the measurements are taken from them, and for each additional set of bases it is advisable to replace and measure from datum lines, not from the work that has been done. Steel fabrication will be proceeding while excavating is in progress, and beams and stancheons cannot be altered to suit setting-out errors.

Registering Levels

The levels of foundation concrete in trenches, raft surfaces, or piers are as important as the wall lines and pier positions ; a dumpy level is an

invaluable aid for this part of the work. The most convenient method is to obtain and securely register the ground-floor level, and measure all depths from it. On an open site, posts, 4 in. by 3 in. or stouter, can be driven firmly in the ground or, a better expedient, bedded in concrete. Their number will depend on the area covered by the buildings, and job procedure ; a post that is convenient enough for one block or wing may be hidden by rising walls before the excavating elsewhere has commenced. On the posts the ground-floor or some other agreed level is marked by a saw cut ; its Ordnance Survey reference, if known, should be put on the post also. After that has been done it is a matter of checking the levels of pegs, excavation bottoms, or concrete below the post datum in relation to the depths shown on the drawings. The same procedure can be adopted for the levels of surface concrete, in which the pegs must always be iron bar or tube, not wood. Even under a wall it is better to eliminate wood pegs, or pull them up as the work of concreting proceeds. As has been mentioned, on enclosed sites the datum levels can be marked on walls ; a pat of cement mortar with the line incised on it is a convenient method.

There are other types of foundations where variations of the procedure mentioned here will be necessary—piling and work under water, for instance—but the general principles of working to frontage lines, accurately positioning walls and piers, and carefully registering levels, apply to them also.

Dealing with Concrete for Foundations

Cement concrete is certain to be the foundation material. There will not be much difficulty with regard to the cement if it is properly sheltered, and protected from damage by rain and surface dampness. The general adoption of the British standard specification for Portland cement has made many of the old specification clauses unnecessary ; if, on being tested, it does not conform to the standard, rejection follows as a matter of course. As the standard tests require special apparatus they have to be made in a laboratory, and are outside the province of the clerk of works on the job. He will be instructed as to the occasions when tests will be required. Where large quantities are used, a frequent custom is to allocate, at the cement works, a bin to the job. After the contents of the bin have been tested and proved satisfactory, all sacks for the job are filled from it until it is emptied ; the number of the bin is stamped on each sack.

Quality and Grading of Aggregate

The aggregate is usually river or pit ballast, or crushed shingle ; and river, pit, or crushed sand. The river and pit varieties of both ballast and sand are not by any means constant in quality and grading. From the river they may contain mud and organic matter ; from the pit, clay.

All these are objectionable ; the organic matter must not be present at all, and the clay only in small quantities. The ballast grading—proportions of sizes of stones or flints, and of sand to them—is another difficulty ; that all the ballast comes from the same pit is not a guarantee of constancy.

River ballast is less variable, but it must not be assumed that the quality of a sample load will be that of all subsequent loads. Dredging is done here and there, and the composition of the river bed is controlled by many factors. Shortage of sand in it is not a serious matter, if enough is added during the gauging to fill up the interstices between the stones, but unsatisfactory grading of stones is not so easily adjusted, and the clerk of works has to use his judgment in this respect. Ballast is suitable only for mass concrete, and a certain amount of latitude with regard to grading is permissible, but there should be enough of the stones from ¾-in. gauge downwards to ensure the filling of voids between the larger ones, without having to use more than 10 per cent. above the standard proportion of sand.

Entirely clean ballast, whether river or pit, is not common, and the amount of inorganic fine material should not exceed 8 per cent. ; in the smallest amount it is objectionable if it coats the stones and prevents their close envelopment by cement. Hard chalk in ballast, rounded as flints are, is found in some districts ; for ordinary mass work, except under heavy loads, its presence does not appear to be objectionable. At any rate, such ballast has been freely used without producing failure.

Quality and Grading of Sand and Shingle

Sand from pits and rivers should be clean and coarse ; for reinforced concrete the proportion of inorganic fine material must not exceed 6 per cent. As, with modern transport, there is no difficulty in obtaining suitable sand in all except remote districts, the clerk of works can insist on an approved quality without hesitation. Rubbing the material between the palms of the hands will, in most cases, enable a decision to be made at once as to whether a load is acceptable ; the well-known bottle test is a longer operation.

Shingle from washing and crushing plants, graded to the specified standard, is necessary for reinforced concrete. Usually it is from ¾ in. downwards ; sometimes, where the rods are close, or the slabs thin, from ⅜ in. downwards. There is not, as a rule, much difficulty with regard to constancy of grading, but there may be with regard to the amount of fine material present. Washing apparatus gets out of order, or becomes worn, and the fact that the shingle has gone through a washer is not a final proof of cleanness. Close inspection of samples and deliveries is necessary, and if loads from a particular plant, from which a sample has been received and approved, vary appreciably, there is no alternative to rejection and asking that a more suitable source be found. Satisfactory

progress of concrete work is impossible if shingle and sand deliveries are a mixture of good and not good.

Placing Mass Concrete

The general rules respecting gauging, mixing, and placing mass concrete with a ballast aggregate are those which apply to concrete with a shingle and sand aggregate for reinforced work, except that the latter are more exacting with regard to such items as jointing new to partly finished work, rodding and tamping the concrete so that it entirely encases the rods, places at which partly finished work can be stopped, accuracy of shape and dimensions, and protection from adverse weather conditions and injury while setting. The path of safety for both mass and reinforced concrete is that defined in the *Code of Practice.*

Checking Proportions of Concrete

Proportions of cement, sand, and shingle (or ballast) will be stated in the specification, and more than one grade of concrete may be required. The size of the gauge boxes will depend on the size of the mixer and the builder's procedure ; he may use boxes for the shingle and sand, and the contents of a hundredweight sack for the cement. The clerk of works must check the box sizes, and see that they are kept clean and filled level with the top, not heaped up. There can be no objection to the sack method, but each sack should be completely emptied for the one gauging.

Water Content

It is desirable that the water content be measured in the mixer tank ; with experience the machine operator gets very close results, but the tank method is better. It has to be remembered that the objective is concrete of a given consistency, not the application of a standard amount of water ; a wet aggregate will need less water than a dry one to produce the same result. When the drum is emptied, the first batch into the barrow is coarser than the next because of the gravitation of the heavier aggregate. This has to be watched when the concrete goes into comparatively thin floor slabs, 5 in. or 6 in., particularly in the bottom layer ; the coarse and fine must be hand mixed, after dumping, by the concreters so that the bottom rods are effectively covered. Near the top of the slab their treading about mixes up the coarse and fine into a homogeneous mass.

Concrete Wall Work

For work in walls between shuttering, the concrete must be spread along in thin layers and well rodded, not dumped in a mass over a small area. If the supply from the mixers is rapid the rodding must be continuous, not done at intervals by the men who are doing the depositing. Where new work joins concrete that has set, the joints should be buttered with a 2 : 1 cement mortar ; this gives an effective joint and prevents the older concrete absorbing water from the new.

The wetness of concrete—its condition as a plastic mass—should be such that when deposited and rodded, or tamped, no surplus water is lying on the top. The ideal mix for maximum strength appears to be one in which the quantity of water is that which is necessary to set the cement and no more, but in practice there has to be enough plasticity for the total surrounding of the rods ; if these are close the concrete has to be wetter than is necessary otherwise.

The slump test should be used at intervals. A 6-in. slump is the limit ; a concrete that gives a 2-in. slump is sufficiently plastic for plain work. With experience the clerk of works will find that, in addition to checking by testing, he can recognise suitable mixes at sight.

Encasing Steelwork with Concrete

For the complete encasure of steelwork, particularly where the covering does not exceed 2 in. in thickness, or is even less, the concrete has to be fairly wet on the soffits of beams ; it must be deposited on one side and tamped until it crawls under and appears on the other side. Around stancheons it must be rodded ; vibrating the casing with a hammer also assists the flow of the particles into a coherent mass. That all rubbish must be removed from centerings, casings, and partly finished work before depositing commences, is an obvious requirement.

See that Rod Sizes, Shapes, and Positions Are Correct

Rod sizes, shapes, and positions will be shown on drawings or bending lists. The clerk of works must see that the sizes and spacings on the centering are correct, the intersections securely wired, the rods free from loose rust, the cranks, hooks, and bobs bent as required, and that the distances of rods from soffits and other surfaces are as shown on the drawings. To keep slab rods the correct distance from the centering, as good a method as any is to cast concrete " biscuits " of the required thickness, break them into small pieces, and place them under the intersections. There is always a risk, in slab concreting, that rods will be pushed downwards too far by the men working on them ; after the bottom layer of concrete has been put in, and they are nearly covered, they should be lifted slightly with a hook and shaken so that the green concrete gets under every part. Barrows must always be trundled on wheeling planks, and not run on any concrete that is not set and hard. For keeping top rods in position various devices are employed. Sometimes $\frac{1}{4}$-in. wiring rods are used which are not part of the reinforcement, and to them the top rods are secured at the correct spacings. The additional rods cost very little, and the method is a reliable one. Where the rod ends rest on steel beams it is possible to make a temporary fixing there.

Protecting New Concrete during Unfavourable Weather

The clerk of works must watch the protection of new concrete during unfavourable weather. Engineers differ in their stipulations respecting

the laying of concrete during low temperatures ; some permit it at 36°, others regard 40° as low enough. Concrete in floor slabs is more exposed than between casings in walls, and no risks whatever should be taken. In their case, although it means the loss of time on the contract, and the stopping of pay of the men, the temperature limit set in the specification should be regarded as final. If speed of construction is an important factor the water and aggregate can be warmed and a rapid-hardening cement used. The extra cost of the latter item is not much, but big-scale warming of water, sand, and shingle is.

Protection is clearly necessary whenever there is a prospect of frost or cold, searing winds. Old sacks, hessian canvas of double thickness, tarpaulins, and other materials are used ; it is a good plan, if the surface of the concrete is not too wet, to lay paper cement bags under the sacks, etc. At the other end of the scale is protection during hot weather, when frequent watering and covering with wet canvas are necessary. Very heavy rain will disturb a surface, but it often comes without warning and cannot be guarded against. In any case the surface can be made good.

Keep an Eye on Loads Placed on New Concrete Floors

One other item that can be regarded as a protective measure is the prevention of the overloading of floors, particularly when they have been laid recently, by the dumping of materials. Stacks of bricks, 4 ft. high and more, will be discovered neatly piled up on a slab that is less than a month old ; nothing breaks or shows visible cracks, so it is assumed that no harm is done. But harm is being done, and the clerk of works must interfere. Loads on slabs above one month old, unless they are exceptionally thick, should not exceed 100 lb. per square foot.

Useful Information on Concrete

In the structure of most buildings where clerks of works are employed, concrete is used for foundations, floors, staircases, lintels, roof flats and slopes, and, in part or entirely, in walls and piers. It is the principal structural material, and the notes given here refer to some of the points attaching to its use which are encountered on the job. Many books, articles, and papers have been published on the subject, some written by engineers with an extensive experience of concrete construction, from which the student can choose the sections that will be most useful to him. One in particular may be mentioned : *The Report of the Reinforced Structures Committee of the Building Research Board.* It is published by H.M. Stationery Office at 1*s.* 3*d.*, and in addition to the recommendations for a Code of Practice, it contains instructions for the making on the job of slump tests and concrete cubes for laboratory tests.

Attention to the Steelwork

In steel-framed buildings the principal items that require the attention of the clerk of works are that the spacings and sizes are as shown on the drawings ; the stancheons upright, in alignment, and close-fitting at the butt joints ; the beams level and true in shape ; the rivets firm, and the bolts properly washered and tightened. Rivets are tested by placing the fingers against one head and tapping the other ; if at all loose a vibration will be felt. Should the specification require that the steel be painted, this will apply to the ends of bolts fixed, and rivets driven, on the job as well as to the steel sections. Bolt and rivet holes must be in true alignment and have not more than the specified clearance.

Grouting for the Stancheon Bases

For grouting stancheon bases the method will be specified. Both cement grout and cement mortar are used, but the latter is the more satisfactory. With grouting the clearance under is usually 1 in., and an enclosure has to be formed into which the grout is poured until it reaches the top of the base-plate. The grout has to be sufficiently liquid in consistency to run underneath, and must be kept stirred in the pail and puddled in the cavity. For a cement mortar packing a 2 : 1 mixture of coarse sand and cement is required, and a clearance of about 2 in. Against three sides of the base or bloom a firmly fixed wood or other kerb is placed, and the mortar is pushed into the void in small quantities and driven tightly against the kerb. If a fairly dry mix is used, and the work done thoroughly, the space under the base will be completely filled ; no voids will be produced later by the evaporation of water. It may be necessary to notch the kerb over the projecting ends of the steel wedges used by the iron fighters to adjust the level of the stancheons ; care must be taken that the wedges are not placed at awkward angles.

QUESTIONS AND ANSWERS

What items do weekly report sheets usually include ?

(1) Number of men employed.
(2) Weather.
(3) Names of visitors.
(4) Numbers of drawings received.
(5) Names of drawings required.
(6) Description of the state of works at the end of the week.

How should the weather be described in the Clerk of Works' weekly report ?

Rain or frost and time lost because of either should be so described. Ordinary weather, when work is not delayed, is, for building purposes, mostly described as " fine."

What should the Clerk of Works' diary contain ?

(1) Most of the statistical items included in the reports.
(2) Particulars of the principal work done each day.
(3) Instructions received from the architect, engineer, or surveyor.
(4) Transactions with sub-contractors.
(5) Any items of importance concerning which information may be required subsequently.

How would you describe the state of works of (1) excavations and foundations, (2) roofs and flats, (3) steel framing ?

(1) Excavations can be recorded as being so much below ground level or ground-floor level. Foundation concrete may be located by its position, e.g. " foundations of N. and E. external walls concreted."

(2) Roofs and flats can be indicated by positions and stages of construction ; pointing as a percentage of the total area.

(3) Steel framing can be described as having reached a particular stage, the stancheon and beam numbers on the drawings being used to describe it ; or the percentage method can be employed.

How would you record the progress of plumbing, heating, water supplies, and electrical pipe services ?

A general statement of the situation at intervals of, say, three weeks is usually sufficient.

How can the Clerk of Works keep a check on the number of men employed for the purpose of his weekly report ?

The number of men will be supplied by the foreman or time-keeper, and an occasional check can be made. When firms have been appointed by the architect, it is advisable to instruct their charge hands to report numbers daily to the time-keeper. On small jobs this is not necessary.

PART IV.—THE CLERK OF WORKS—PRACTICAL WORK—CONCLUSION

IN brickwork the correct spacing of parts—window and door openings, recesses, piers, string courses, and other surface variations—is a matter requiring greater vigilance than correct methods of bonding. The latter were of great importance when the lime mortar used was much weaker than the bricks. On most jobs now, the mortar is composed of cement and sand, or of lime, cement, and sand, and bonding becomes a condition of pattern and orderly arrangement rather than a fundamental part of the strength of the wall. This fact can be observed where fractures have occurred through settlement: they run in a more or less continuous line through bricks and joints, not in a stepping along bed joints and perpends. A 5 : 1 cement and sand mortar, if not allowed to become stale, is quite strong enough for ordinary walls, but the tendency now is to use a lime-cement mortar to reduce the risk of efflorescence, the volume of cement being about one-fifth of the volume of lime.

What to Look for in Brickwork

The facing bond is usually specified—English, Flemish, or a pattern in which the number of stretchers exceeds the number of header courses. Internally it does not matter very much whether the bond in walls above $4\frac{1}{2}$ in. thick is English or Flemish. Where internal $4\frac{1}{2}$-in. walls are built later than those outside, toothings should be left for them, not indents, even if these do interfere with the bricklayer's line. In narrow piers a lot of closers look very spotty; where good mortar is used three-quarter bricks are preferable, if the reveals are not more than $4\frac{1}{2}$ in. Otherwise the traditional method of using closers is the more convenient.

Bricks should be laid with frog upwards, the cross-joints be fully buttered, and the wall joints be filled in, not merely surfaced. Grouting every three courses is sometimes specified, and means the slurrying of mortar so that it runs into the wall joints, but working the mortar into the joints with the edge of the trowel is a sounder job. If, however, the wall joints are very close there is no alternative to grouting.

Protecting Partly Built Walls from Rain and Frost

Boards, felt, or other coverings must be placed on partly built walls to protect them from rain and frost. Disfigurements of facings by scaffold splashings must be avoided as far as is possible—at all times except when heavy rain comes while work is in progress—and joints must be fully raked out for pointing—not less than $\frac{3}{8}$ in. deep—if pointing is not being done in the walling mortar.

See that Brick Deliveries Conform to Sample

The kind of bricks to be used will be specified, and approved samples supplied to the clerk of works, who must see that deliveries conform to the samples. Multi-coloured facings sometimes present difficulties with regard to length and colour. The source of supply is usually chosen by the architect, and if a standard length is required it is the brickmaker's business to provide it : the builder cannot be expected to sort out sizes unless he is paid to do so or has chosen the bricks himself. On the other hand, variations of length may be accepted by the architect, in which case irregular lines of perpends cannot be avoided ; with coarse, flush pointing they are not conspicuous. But this question of length in hand-moulded bricks is a matter which the clerk of works should investigate at an early stage of the job. It may not arise ; if it does he should obtain the architect's decision.

Are Brick Colours Satisfactory ?

Where there are variations of colour—browns, reds, and purples, for instance—the delivery of satisfactory proportions of each requires attention, and the avoidance of patches of any one colour in laying. The best plan is to have a sample piece of wall built, say 4 ft. by 3 ft. high, and approved. If the labourers carrying the facings to the scaffolds are selected and kept at it they will soon get the right idea, as will the bricklayers, but the crux of the matter is getting deliveries from the brickyard in suitable proportions of colour. Pink in bricks is a danger signal ; nearly always they are soft.

As common bricks are usually obtained from yards where expensive plant has been installed, adjoining extensive deposits of suitable clay, quality does not vary very much. Flettons, gaults, and similar bricks with a face that is not rough enough to give an effective key to plaster, can be obtained with undercut grooves on the face for plastering : the advantage gained by using them justifies the small additional outlay. If the builder is instructed to use keyed bricks when they have not been specified he can claim an extra ; the alternative is rough-raking the joints, a cheaper method, but not so satisfactory.

Underpinning

For underpinning the bricks must be hard, of good shape, thoroughly soaked during dry weather, and laid with all the joints completely filled. It is done in short lengths, and proper toothings must be provided for the adjoining sections ; it is desirable that these be protected with felt or a similar covering to exclude the material that is excavated in adjoining bays. Slates in cement are usually specified for pinning up to existing work ; a sound method is to use stiff cement mortar, or fine concrete, and drive it into the gap between the old work, which must have been thoroughly cleaned, and the new work, which must be set and hard.

Underpinning can be an unpleasant job in a confined space, obstructed by timbering. A brick wall face, not less than one and a half brick thick, with concrete behind it which completely fills the irregularities at the back of the excavation, is, in some circumstances, a safer method than using brickwork alone, but the brickwork must be firm before the concrete is put in and bonded to it, and the concrete must be of suitable consistency and well punned.

Some Pointing Defects to Look for

Pointing snags, apart from unraked joints and frost damage, are variations of colour, irregular struck joints in perpends, insufficient filling of joints, and work done on wall faces that are not properly cleaned. The three latter defects can be detected by direct observation ; variations of colour of the pointing mortar are not so easily seen until the pointing is dry and a large area has been completed. The remedy is to select a sand which gives the shade required, obtain a large quantity of it for pointing alone, and keep the same labourer on the job of proportioning the parts and mixing them until the work is completed.

Temperatures at which Bricklaying Can and Cannot Be Done

The temperature limit downwards, at which bricklaying can be done without injury, is lower than that of concrete. If the mortar and bricks are free from frost, and the temperature is rising, work can be commenced at the beginning of the day with the thermometer at 34°. The mortar is the vulnerable material, and it is partly protected as soon as a brick is laid on it. Freezing-point is too low at any time of day unless special precautions are taken of a nature similar to those mentioned in the notes on concrete. As frost plays havoc with pointing, that operation should not be performed when frost is present, nor when it is probable.

Dealing with Portland Stone

The clerk of works in London and the south of England will, on substantial contracts, meet Portland stone more often than any other. It weathers better than most limestones in town atmospheres, is available in large sizes and quantities and, when new, is pleasing to the eye, particularly in contrast with neighbouring buildings that have the grime of many years on them. It should be laid on its natural bed, be hard, and be free from cracks and " vents."

The direction of shells in the stone usually indicates the natural bed : they lie more or less parallel with it. Hardness can be ascertained with a knife ; a little experience and experiment will give the information required. Vents are voids within the stone that, under strain, may produce surface cracks. A stone entirely free from them emits a clear note when gently tapped with a hammer ; one containing voids gives a

dull note. Obviously there are notes between the clear and the dull, and the quantity of moisture present, apart from defects, affects the sound. But the notes should be clear, and doubtful stones must be washed clean and examined closely. Stone is a natural material ; an unvaried standard of quality is not obtainable except in small quantities, but all stones containing vents should be rejected.

How to Prevent Staining of the Stone

Courses should hold up to the specified thickness ; odd pieces broken off at the back corners will not do any harm, but neither will an excess of specified thickness in one part balance a deficiency in another. As Portland stone ashlar is usually a facing only, backed with brickwork in cement mortar, precautions have to be taken to prevent surface staining by the cement. Proprietary liquids can be obtained for this purpose, and are painted on the back and ends of the stone. An effective method is to well wet the back and rough plaster it, about $\frac{3}{8}$ in. thick, with a mixture of 2 sand, 3 stone dust, and 1 pre-hydrated lime. The back must be completely covered. Joggles should be thoroughly wetted and run with a mixture of lime, cement, and stone dust.

A problem in steel-framed buildings, where the cornice or other projecting horizontal parts, and sometimes vertical parts, cannot be given enough bed to balance the overhang, is solved by using galvanised bolts and ties. They are usually placed in the joint where stone meets stone, half of the large square washer at the outer end of the bolt being housed into each stone, grooves provided for the bolt, and the whole grouted. The inner end of the bolt is secured to the stonework in whatever manner is most suitable in the circumstances. There are many ways in which this anchoring to stonework can be done ; the essential points are that the ties be of galvanised steel or a non-corrosive metal such as bronze, the joints be filled in solid, and sufficient thickness of stone be provided to resist strains.

Cleaning Down the Stonework

A mechanical carborundum wheel is sometimes used for cleaning down. The clerk of works must see that a wavy surface is not thereby produced. If it is, stop the use of the wheel and require that the stone be cleaned by hand.

Other Types of Stone

Some of the points mentioned above apply to all building stone ; others do not. It matters very little, for instance, whether good Ketton stone is laid on its natural bed or not. In Cambridge there are walls over a century old where the blocks are edge bedded and face bedded, but no disruption has occurred. Other stones are not susceptible to cement stains ; in others the natural bed is visible without reference to shell

positions ; and there are stones that are not nearly as hard as Portland stone but quite suitable and lasting in some atmospheres.

In the British Isles a number of excellent building stones is available ; often there are differing beds in the same quarry. Weldon stone varies from very coarse to comparatively fine ; Ancaster stone has a fine bed and a pronounced shell bed ; some Ketton stone has a tinge of pink in it, and Hornton stone a shade of blue. If a large quantity of a stone that is new to him has to be used, the best thing that the clerk of works can do is to visit the quarry and, if possible, inspect some buildings containing it which have been exposed to the weather for several years, but these should be situated in places where the conditions have been similar to those which his new building will have to endure. He will find that stonemasons who are familiar with a stone that he has not met before can be very helpful, if he does not "throw his weight about." Their opinions are nearly always valuable, particularly in the provinces.

Stone for Paving and Steps

Stone for paving and steps—usually York stone—must be hard, close-textured, and free from laminations ; samples should be obtained for approval. There is not much difference between brown and blue York for external pavings ; they soon get to look like each other.

Protecting the Stonework

The protection of parts that can easily be damaged—plinth tops, window cills, projecting heads, cornices, string courses, blocks for carving, stair treads, and angles generally—is a matter requiring the attention of the clerk of works. Replacing damaged bricks is easily done ; cutting out and replacing damaged stone is not, particularly long lintels and steps. A useful device to secure boards on plinth tops and other awkward projections is to build into the joints some strips of zinc, which can be cut off when the risk of injury is over. All steps and landings should be protected, whether in natural or artificial stone, marble, terrazzo, or any other finish.

Stone Substitutes

Stone substitutes range in quality from the excellent to the too cheap. No general rules can be suggested, but practical tests can be made for : hardness ; brittleness ; firmness of surface ; resistance to abrasion and water absorption ; ease or difficulty with which stains can be removed ; freedom from crazing and surface defects. In making such tests it is clearly necessary to bear in mind the places where the substitutes will be used, and the probable agencies that may cause damage.

Shuttering

Much of the skill of the carpenter on modern buildings is applied to the fixing of concrete shuttering—pillars, slabs, roof slopes, lintels, and

structural steel encasures. Steel bolts, hangers, wire, and gadgets enter into it and, for struts under slabs, there are mechanical props of the telescopic type. It is not high-grade craftsmanship, although obtaining a large slab soffit that is free from waves does require close attention. Framing and boards get warped and require pieces of packing ; they may vary in thickness, wedges can become loose, and struts get knocked out of place. The clerk of works can check most of these items without difficulty ; he has also to see that Building Act or by-law cover is given to the structural steel, and that surfaces are level, upright, or to whatever shape is required.

Smooth-finish Concrete Work

If the specification calls for a smooth finish, tongued and grooved boards can be used, but a better method is to have a rough centering and put masonite or a similar hard wall board on it. Lino has also been found effective in obtaining a smooth concrete ceiling. When wall board is used the rough centering under can have open joints. On the whole, wrought centering is an advantage for any ceiling ; it does not leave splinters in the concrete, is more easily cleaned for re-use, is constant in thickness, and enables the carpenter to take a little more interest in his work. Shutters with rails spiked to them, about 4 ft. high, to the correct width and wired together, strutted for reinforced concrete pillars, and kept in position by temporary distance-pieces on steel stancheons, are used for vertical casings.

Structural Timbers

The use of large quantities of wood in shuttering—or centering, if that term is preferred—has partly removed one of the difficulties formerly encountered by clerks of works. The inferior scantling and boarding that formerly reached the job for structural carpentry, and had to be rejected, is used up. Structural timbers should be free from blue and other discolorations, waney edges, appreciable shakes, and large or disintegrated knots. Some sapwood can be expected, and if it is not discoloured, is bright when planed, kept dry, and used in places that are ventilated, no subsequent trouble is probable. These remarks apply to structural wood in rafters, joists, hips, ridges, etc. ; wall plates, joists on or in concrete, fixing grounds and other parts in close contact with brickwork and concrete, should either be free from sapwood or be coated with a protective —creosote, cuprinol, or other preservative. British Columbia pine usually has no sapwood ; its rings should be about 14 to the inch, and the clerk of works must see that it is not split by nails during fixing. A point to be observed is that stacks of wood delivered are sheltered from rain by tarpaulins or other suitable coverings.

Grounds for Skirtings, Architraves, etc.

Grounds for skirtings, architraves, hardwood linings and other finishings must be securely fixed without a lot of packing. In external walls, hardwood plugs should be used unless some kind of fixing brick has been provided; if it has, inspection should be made that it really does hold nails, which are not loosened by jarring. That the grounds should be straight and true, and at least $\frac{1}{4}$ in. within the edge of the finishings, is obvious. The specification will describe the joints that are required for angles in skirtings, etc. A tongued and grooved joint in internal angles is a paid-for item, not a necessity, unless described in a general preliminary clause. In the latter case the builder must provide it and settle the question of payment with the surveyor. Hardwood jambs and linings should be screwed and pelleted; skirtings, architraves, and other mouldings fixed in places where the nails or brads are inconspicuous; and panelling fixed so that it is secure, but has the minimum amount of stopped holes or pellets. It is usually possible to do hidden fixing under the skirting and cornice, and sometimes under a dado rail. Slot-screwed fixing is an expensive method, and will be specified if required. All panelling should be painted on the back; when finishings are surface painted the above-mentioned secrecies do not apply.

When Fixing Joinery and Hanging Doors Can Be Commenced

A frequent problem is to decide the date when fixing joinery and hanging doors can be commenced. The ideal condition is that the building should be as dry as the shop from which the joinery has come; very rarely is this possible. Speed of construction is usually essential, and the joinery comes into a damp building, swells, and later shrinks. The clerk of works must do what he can to get the building as dry as possible by putting the central-heating system into commission, using fires, keeping the windows open when dry winds are blowing, getting the floor screeding done at an early date, and there may even be occasions when electric fans will help. He can also see that the joinery is not delivered and stored on the job several weeks before it is required. Atmospheric moisture, not direct wetting, does the damage. If he stays on the job until occupation has taken place he can caution those responsible not to keep the heating system running full blast in rooms that have the doors and windows shut.

Matching Veneers

The use of veneered plywood and laminated board in flush doors and panels has removed some of the risks of shrinkage. A point requiring close attention, where they are in figured hardwood, is the matching or balancing of the patterns and tints of the veneers; fairly frequent visits to the joinery works may be advisable. Architects have a wide choice of hardwoods now, particularly Indian and Australian; some of them are

strongly figured, and a successful result, in both framing and panels, depends more on the selection of figure than on details of construction. This applies in a lesser degree to oak, walnut, and the other more familiar hardwoods where variations of figure are not so obtrusive.

Joinery Work

The cabinetmaker's dowelled joint is frequently used in modern joinery—two rows at the ends of rails in thick doors ; and has the advantage, if properly made, of confining shrinkage to the outer edges of stiles. Laminated board panels in wall panelling may be buttoned to the back of the framings, not tongued into them. Solid flush doors, built up with strips, are better than the skeleton-framed ones ; there is less tendency to warp and—a particularly important point in institutions and flats—they obstruct the passage of sound much more effectively. It is an advantage to supply drawings of doors and similar framings to the builders at an early date, so that the framing can be milled, assembled loosely, and allowed to " find itself " before gluing up is done.

Identifying the Hardwoods

For the identification of hardwoods—the various kinds of oak and mahogany, the difference between teak and Iroko, and so on—the inexpert must consult reliable books on the subject, including the publications of the Forestry Research Board, or get the advice of experts. Small samples can be deceptive ; the reliable test is to mount sections on slides, inspect the cell and fibre pattern through a microscope, and compare with known examples, but some laboratory experience and rather expensive apparatus are needed for it.

Checking the Ironmongery

Ironmongery will probably be selected by the architect, and the clerk of works supplied with approved samples. An orderly schedule should be prepared and checked, and such points noted as the suitability of the locks for narrow stiles, depth available for floor springs, and so on. Where the locks are suited, particularly if there are several sub-suites, and a grand master key for all, the makers must be given the time they ask for to do the work ; it may be three months or more, even when trade is not brisk.

Plastering

The advantages accruing to modern plastering because of scientific research and practical experiments are the result of improved materials. Traditional methods of application have altered little ; mechanical aids have not replaced the manual skill of the plasterer. Many of the new materials differ from the older with regard to gauging, periods between

the application of coats, and the laying on and trowelling off of setting coats, but in this respect there have always been local problems: the lime in one district has to be treated differently from the lime in another district.

Proportions of Ingredients

Pre-hydrated limes, hard plasters, and cements of many kinds are now obtainable; mostly they are marketed under proprietary names. The limes are sold in powder form and can be used without any preliminary preparation, just as Portland cement is used. It is, however, an advantage to make coarse stuff containing pre-hydrated lime—render and floating coats—at least one day before it is applied, and knock it up again so as to secure greater plasticity and easier spreading. The clerk of works should, if a fairly strong lime is being used, find out what the makers have to say with regard to mixing, and also make his own experiments. Chalk lime—whether pre-hydrated or lump—has, in any case, to be made into putty for setting coats, but the former can be used within a week, and the latter should lie in the bin two months before application.

Of hard plasters there are many, each with its own characteristics. Some are baked at plaster of Paris temperature, and contain ingredients that prevent a too rapid setting; others are hard baked and contain accelerators to speed up setting; and there are intermediate grades. Portland cement backing—4 : 1 is strong enough—and a hard plaster face are frequently used; or hard plaster, in coarse and fine grades, for all coats. But, whatever the materials may be, the finishing coat must not be harder than the undercoats.

A method that has a lot to recommend it, where a lime plaster finish on solid walls and ceilings is permissible, is to use a mixture of pre-hydrated lime, retarded plaster, and sand for undercoats, and lime and sand for finishing; 7 sand, 2 grey pre-hydrated lime, and 1 plaster for rendering, and an addition of 1 part of sand for floating; angles in Portland cement backing and hard plaster. Lime plaster is a little less resonant than hard plaster and more absorbent, an advantage during humid weather; on the other hand it takes longer to become firm, and therefore cannot be completed so quickly.

Sand should be coarse for undercoats; up to 8 per cent. of fine material in it will not do any harm if used with lime plaster. The length of periods elapsing between the application of coats should be such that the projecting parts of the scored key will have become hard and not be broken off or flattened when the next coat is applied; under the setting coat the surface should be coarse, stiff, and firm. Newly plastered surfaces must be protected from wind and frost—windows being kept shut and doorways screened, and in dry weather, undercoats must be well wetted before the next one is put on.

Spotting Defective Plaster Work at an Early Stage

In more than any other trade a good result—a straight, clean surface, free from waves—depends on the skill of the operative, which only practice can give, plus sufficient time to do the work properly. Straight-edges on accurate screeds and grounds produce a true floating coat, but a true setting coat—one of even thickness on the floating—is obtained only by laying on the right quantity, allowing the correct time to elapse, and then applying a constant and even pressure in working off a finished face. Patching irregular or wavy places on finished plaster is of very little use ; if a surface is too rough to be accepted the only thing to be done is to replaster it. It is here that the clerk of works is so often up against the time factor, hence the need for vigilance and spotting defective work at an early stage. Irregularities are not easy to see until the surface is dry and the light good, but they can be felt. Making good around pipes, to tile, grano, terrazzo, and other skirtings and dados, and to damaged places, must be reduced to a minimum. It is difficult to disguise, particularly on painted surfaces, but rubbing down projections and filling the thereby roughened face with distemper paste, alabastine, or similar hard stopping, will reduce the disfigurement substantially.

Keys for Plaster

Surfaces on which plaster of any kind is applied must have a good key ; that is, there must be interstices into which the plaster can enter and obtain a firm grip ; high-grade materials are not a substitute for this provision. Most baked-clay partition blocks and bricks can be had with a dovetailed groove formed in them, and the surfaces of breeze and other cast blocks and slabs are sufficiently rough in themselves. Some bricks, such as the London stock, provide anchorage without grooves. But there have been a number of plastering failures on concrete ceilings, where large slabs have fallen away. Coating the shuttering with a proprietary liquid, which retards the setting of the surface cement sufficiently to enable it to be brushed away and leave a key in the recesses of the aggregate, is one method adopted. Sprinkling a layer of dry broken brick on the shuttering, which becomes only partly enveloped by the cement and sand, has been used, but should not be unless the engineer consents ; and another method is to lay thin (about $\frac{1}{2}$-in.) rough baked-clay keyed tiles on the shuttering in the spaces between the rods ; these are firmly gripped by the concrete and do not affect the rod cover.

Hacking with a miner's pick, if thoroughly done so that there are rough pits about 5 in. apart, gives a key that will ensure firm ceilings if the render coat is gauged. The pick point soon blunts and becomes ineffective, so several are needed, and frequent visits to the smith. On hacked ceilings the plastering should not be more than about $\frac{5}{8}$ in. thick, except small areas, where another $\frac{1}{4}$ in. or so may be required to get a

straight face. Where the concrete is of such a shape that, to get straight plastering, 1 in. and more has to be put on over an area of several yards, a false ceiling should be formed with suspended rods and expanded metal.

Examining the Plumbing Fittings

The plumbing specification will describe the quality of iron, lead, and copper pipes required, the sanitary fittings, methods of fixing, and other salient items. Often the sanitary fittings are selected after the building has been commenced, but should be done early enough to have samples on the job for the plumber at the commencement of his work, so that he can get positions of waste outlets and water supplies. The clerk of works should closely examine the fittings for twisted shapes, cracks, crazing and pits in the glaze, and mechanical defects in the waste preventers ; obviously he must see that the tubing and pipes are as specified and the valves not under-weight.

Supervising the Plumbing Work Efficiently

The runs of pipes may be described in general terms in the specification, or shown by lines on the plans and sections. In any case the surveyor has had to assume runs when taking off his quantities, so, in the absence of other information, the clerk of works should consult him on this point. It is, however, necessary to collate the plumbing pipe runs with those of the other trades before fixing commences, otherwise there will almost certainly be a clash between the hot-water fitters and the plumbers.

The clerk of works will save trouble later if, early in the job, when he has time to spare, he draws, to $\frac{1}{4}$-in. scale, sections or elevations of the parts of the building containing the lavatories—often they are grouped on several floors above one another—puts in all partitions, windows, and steel framing, and marks the pipes in different colours. Allowance for sizes of pipes and their fixings, and the gradients of hot-water pipes, must be made, and the positions of wastes and stacks. Cleaning-eyes for wastes and valves for water pipes should be indicated and, as far as is possible, heights above floors and dimensions and positions of risers in relation to walls or partitions. Cleaning-eyes must be located so that any stoppage can be cleared without difficulty, and valves so that the minimum number of fittings are cut off during repairs. Information on most of these points will exist in one form or another, but usually it has not been collected on one drawing ; so it is an effective form of supervision if the clerk of works does it himself at a convenient season and gives tracings of his results to the trade foremen concerned.

Disposing of the Piping Systems Neatly

The objective, apart from providing an efficient system, is to dispose of the pipes as neatly and inconspicuously as possible. Plumbing ducts

are often provided, but the architect does not allot more space to them than he can help ; sometimes they are decidedly cramped and nearly filled by the pipes—soil stacks and branches, vent pipes, and hot and cold supplies. As they contain the valves and cleaning-eyes, the door must be large enough to give easy access to these fittings ; the hot-water pipes must be lagged with hair felt or loose pipe covering. In large kitchens, the provision of sufficient valves and cleaning-eyes is particularly important ; there should be a cleaning-cap at the end of all waste runs.

Urinal Fittings

Placing urinal traps where the cleaning-cap can easily be reached is sometimes a problem : a projection below a ceiling may be unavoidable. The grating over the outlet of the channel prevents pieces much larger than match sticks from passing into the waste, but the provision of caps is desirable. Another point is that where the urinal is not raised the floor surface should fall to it for a distance of at least 2 ft. from the channel, and that on upper floors it is desirable to put one coat of asphalte under ranges of urinals.

The One-pipe System

The one-pipe system reduces the number of stack pipes ; the w.c., lavatory basin, and sink wastes enter the same soil stack, the anti-siphon pipes the same vent stack. If there are lavatories on several floors above one another the soil stack increases in size as it goes down and the vent stack as it goes up. All traps must have not less than a 3-in. seal, and all vent branches be not less than $1\frac{1}{4}$ in. in diameter. All waste pipes, of whatever kind, must be ventilated. Sound materials and workmanship are fundamental in plumbing ; the plumber of the comic papers should be paid off quickly.

Iron Drain Pipes

Iron drain pipes, like iron soil pipes, should have a clean bore, and branches should be as near to the correct angle as stock sizes permit. Where the direction does not fit a standard angle, bends have to be used and cut so that the pipe line has a clean run without kinks in it. Testing will be done by the local authorities, but the clerk of works should see for himself that the spigots and sockets are flush inside and not projecting one above the other to form ledges. Suspended pipes require strong hangers of the holderbat type, at least $\frac{1}{4}$ in. thick. It is advisable to consult the sanitary inspector, or other official in charge of drainage, before operations are commenced, when problems arise connected, for instance, with difficulties in getting the prescribed fall, or connecting old work to new. The clerk of works should record any deviations from the original plans so that, at the end of the job, the building owners can be

given accurate drawings of all runs, manholes, access pits, and lists and locations of sanitary fittings connected to the various drain branches.

Builder's Work for the Engineering Services

Builder's work connected with engineering services includes holes and chases; boiler, pump, and motor beds; boiler flues for heating and domestic services; ducts, inlet and outlet openings; fan and motor beds, and heating, washing, and cooling-plant services connected with ventilating; chases, recesses, and holes for electrical work; and cutting and pinning, holes and beds, for lifts. Drawings showing builder's work connected with engineering plants are usually provided for all except the small pipe runs; if not to hand at an early stage of the job the clerk of works should ask for them.

Pay Close Attention to Holes for Piping in Concrete Floors

Where solid concrete floors are used it is very necessary that plans should be provided, before the floors are cast, giving hole positions and their approximate sizes, to reduce to a minimum the expensive, noisy, and wasteful process of cutting holes later. Here, as with plumbing, collation of plans is necessary to avoid clashing. Various devices are employed to form holes—wood boxes, tapering wood plugs, or tubes which can be knocked out easily, cardboard tubes, and plaster blocks which can be cut out quickly. The hole positions are marked on the centering and the moulds lightly nailed to the boards; where nailing is impossible the concrete is hand packed around the moulds before general laying is done.

The clerk of works will save later difficulties if he pays close attention to this part of his work, both in checking the plans and watching the forming of holes in the concrete. Where precast floors of the trough or hollow-tube type are used it is necessary to see that the webs, which must not be cut, are so arranged that they do not come on the line of pipe perforations. Sometimes it is necessary to leave a gap between the precast units, which is filled in with solid concrete when pipe fixing is completed.

Burying Electric Light and Power Tubes

A not infrequent practice is to bury electric light and power tubes in floor slabs, in order to avoid the depth of screeding that would be necessary if the tubes were laid on the surface. They have to be arranged so that they are above and not under the reinforcing rods, and must have wiring boxes that are deep enough to extend to the plaster face. The critical point, when this method is adopted, is to locate the positions of ceiling boxes accurately, so that they are in their proper places when the rooms below are completed. The ends of the tubes from which the switch drops will be extended must be within the thickness of the wall or partition, and not extending into the room, particularly a room without a cornice. Care has to be taken to exclude water from the tubes by having

sound, painted joints, and to see that the boxes are not moved or damaged during concreting. A good foreman electrician is required if this type of construction is to be done satisfactorily, and he should mark the runs on his drawings when the tubes are laid. One drawback of the method is the risk of damaging the tubing later on when, for some unforeseen purpose, the concrete has to be cut.

Chases in Walls

Chases in walls present no difficulty. If for hot-water pipes they must be wide and deep enough to allow for lagging. It is a common practice to build in central-heating pipes in chases, not to fix casings over them, by covering with expanded metal which is placed flush with the wall surface and wired to $\frac{1}{4}$-in. rods pinned into the mortar joints, about 1 ft. 6 in. apart. Another practice is to make the chase deep enough to allow the front to be filled in with bricks on edge or partition block. In each case the wall surface is plastered across the chase ; both methods are satisfactory if properly done, but the pipes must be lagged and the chase be continuous through the floors.

For electrical services chases should be provided for all large tubes and cables during wall building, but, as a rule, it is more convenient, and not more expensive, to cut chases afterwards for the usual $\frac{3}{4}$-in. tube drops or risers to switch points and wall brackets. Where hot-water pipes penetrate floors in lavatories, bathrooms, etc., the provision of sleeves projecting about $\frac{3}{4}$ in. above the floor is advisable ; for central-heating penetrations to radiators in domestic rooms and corridors, floor plates around the pipes are preferable, the sleeves being only about $\frac{1}{4}$ in. above the floor.

Boiler Flues

Boiler flues, both horizontal and vertical, will be lined with firebrick and a cavity provided ; or moler-earth bricks, which are built close against and occasionally bond into the common brickwork. The moler-earth bricks, and the mortar aggregate used with them, must be thoroughly soaked. In horizontal flues 2-in.- or 3-in.-thick fire-clay slabs are usually placed on the top, with precast slabs over them and a cavity between. Firebricks must be laid in thoroughly soaked fire-clay, the joints being completely filled, and the bricks hand tapped into the bed. Firebrick must be hard, ring clearly, and be free from cracks and crumbling places.

Beds for Plant of all Kinds

Beds for boilers, pumps, and other pieces of plant are usually straightforward pieces of construction ; accuracy of setting out and in levelling is essential, and the provision of cork or other insulation under the beds of all noisy units is required.

Points to Note about Ventilating Ducts

In ventilating systems, the brick ducts are either flush pointed or cement rendered ; when small in area, provision must be made for the complete removal of all droppings ; the clerk of works must see that the rendering is smooth, not merely rough parged as a smoke flue is. Space is usually provided above false ceilings for sheet-metal horizontal ducts ; sometimes the space between the real and false ceilings is itself a duct, and care has to be taken to ensure that it is airtight. Access via airtight doors should be provided where possible ; another point to be watched is the disposal of duct valves so that they can be operated when the inlet and outlet systems are balanced at the end of the job.

Lift Wells

The most important point connected with lift wells is that the walls containing them, or the edges of slabs where they rise through stair wells, should be upright. Where the lift rises through several floors, particularly small service lifts, this is more easily said than done, and an occasional check is advisable. The lift sub-contractors will provide drawings showing holes for cleats, etc. Another matter requiring attention is the clean finishing of concrete floors on the edge of lift wells and, if steel beams bound it, a fair-faced concrete encasure on them.

Time Required for Lift Erection

The clerk of works must not underestimate the time required for lift erection. A lift is the most complicated piece of large-scale construction in a building and, although firms will make optimistic promises, it is better to assume that six weeks at least will elapse between the commencement of erection in a clear well, say five floors high, and the final adjustment of controls and signals. He must also closely inspect the drawings to find out what is builder's work and what is the lift firm's work.

Generally, in mechanical and electrical engineering, the clerk of works will be very unwise if he instructs that alterations be made without consulting the persons who are ultimately responsible for efficient service. When he finds that some part of the architect's details does not fit in with the engineer's, he should refer the matter to them, unless it is a small point, such as a pipe run, that can clearly be rearranged without affecting the effectiveness of the system.

Supervision of the Decorating Stage of Work

When the decorating stage is reached the job is nearly at an end and the most important work has been done ; all that remains is to apply coats of appropriate coloured liquids, partly to protect the materials, and partly to please the eye. To the clerk of works protection is the more important factor. He must see that all rust is thoroughly removed from

steel and iron by wire brushes before painting is commenced. On painted metal windows he should get at least two coats put on the shop coat before they are fixed. On all painted work, metal or wood or plaster, it is desirable that the coats should, for identification purposes, differ in tint; if the finishing colours and tints are unknown until a late stage of the job it will be safe to use whites, creams, and even light greys for undercoats. To avoid the frequent taking down of radiators it is desirable that all except the last coat be applied before they are fixed, but this is not always possible when heating is required during the plastering period. It may be a part of the heating sub-contractor's work that he disconnects and refixes radiators once after he has done the first fixing.

On walls and ceilings little difficulty will be experienced with distempering if the plaster is fairly dry and the colours stable. Painting is another matter. The structural work in the walls—brick, concrete, partition slabs, etc.—should be dry, in addition to the plaster, particularly when the wall is painted on both sides. A coat of the primer for painted plaster, which is sold under various names by most reputable paint firms, should be applied, and on it the three or more specified coats of paint. If a flat finish is required it is better to use a gloss paint and stipple it than to use a flat paint. Plaster surfaces should be thoroughly rubbed down with glasspaper, both to provide a key and to remove excrescences, and all holes and cracks be filled before any painting or distempering is done on the plaster. As far as possible all the work of other trades should be completed before the final coat is applied. Some painters are untidy creatures, and the clerk of works should see that dust sheets are used for the protection of floors and fittings, and that paint splashes and smears are wiped off before work is passed as being completed.

Other Materials and Processes

There are many building materials, and processes connected with them, that have not been mentioned in these articles: asphalte, including coloured and acid-resisting; acoustic plaster, tiles, and felts; asbestos pipes and sheets; wood-block, jointless, rubber, and other floor coverings; slating, tiling, and other roof coverings; roads and paths; metal fittings such as bookstacks; polishing and cellulose painting; and a number of materials that are substitutes for more familiar ones, sometimes cheaper and not so good, sometimes better, and often substitutes that only offer two ha'pennies for a penny. Some of them the clerk of works will meet on most jobs, all of them sooner or later. He can get information about them here in MODERN BUILDING PRACTICE and in other publications, and by consulting those of his acquaintances who have first-hand knowledge of their value.

BRICKWORK OPERATIONS

BUILDING AND POINTING WALLS—ARCHES—NOTES ON CRAFTSMANSHIP

BUILDINGS are usually set out from a given frontage line, the proportions of which are set down on the plans, or from instructions given in the specifications. With the frontage line once established, the positions of the flank, dividing, and back walls can then be marked out. A large building square should always be available, and this should be checked by the application of measurements shown in Fig. 1.

When the approximate positions of the walls have been ascertained, a profile is erected at each end in such a position that it will not require to be removed by the digging operations (see Fig. 2). On these profiles, the width of the trench for the excavator is marked with either nails or saw-cuts. Lines are drawn from the respective profiles, and the positions are transferred on to the ground. When the excavating and concreting are completed, the bricklayer places lines over the profiles on the wall positions, and transfers these on to the concrete foundations, in order to build the walls in their respective positions (see Fig. 2).

Where projections from main walls are other than square or rectangular, it is best to procure a mould, framed up from some light timber, in order to set out the work.

Where the projection is segmental or semicircular in shape, the work can be set out either with a mould or with a trammel. The centre or striking-point is found, and a nail as a pivot is fixed to a stake driven in at the radiating-point. From the radiating- or striking-point the trammel arm is traversed, and the brickwork placed to suit. As the wall rises in height the trammel is also raised on the pivot, and each course must be levelled out and the trammel arm placed over it for its position. For example, see Fig. 3A. When constructing the foundations to buildings, the relative positions of the drains and gas and water pipes should be ascertained, in order that holes may be left in the walls for the pipes to enter the building. It is best, if possible, to construct a rough semi-arch over any large pipes, to prevent fracturing from direct contact with the wall above. The arch should be turned over the pipe on a layer of sand shaped over the top of the pipe. Brickwork to inspection chambers in drainage systems is more easily set out if a temporary, light-framed timber mould, the internal size of chamber, be used for setting out.

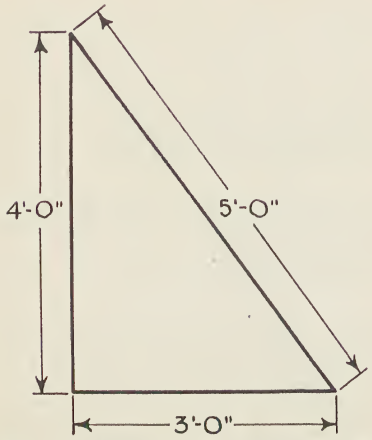


Fig. 1.—METHOD OF SETTING OUT SQUARE ANGLE WITH MEASURING TAPE

Profiles for Walls and Partitions

Where possible the external corners of buildings are first erected, and the intermediate brickwork built afterwards. If the walls are of a considerable length it is frequently necessary to build the wall in sections. In order to save time, and the expense of erecting intermediate brickwork as corners from which to draw lines for the remainder of the wall to be built, profiles can be used. The profile for this purpose is made of fairly stout boarding; it should be weighted down with bricks, made vertically upright with the faces of the wall, and the height of the courses of brickwork marked upon the vertical portion. An example of this type of profile is shown in Fig. 4.

Profiles for Partitions

In order to keep slab partition walls upright, and to prevent them from buckling while being erected, temporary timbers or profiles are erected at the angles or in the middle of the walls. The slabs are built against the temporary stud to give support until the initial set has taken place in the cementing material.

Where the partition abuts a door lining it is best to construct, with

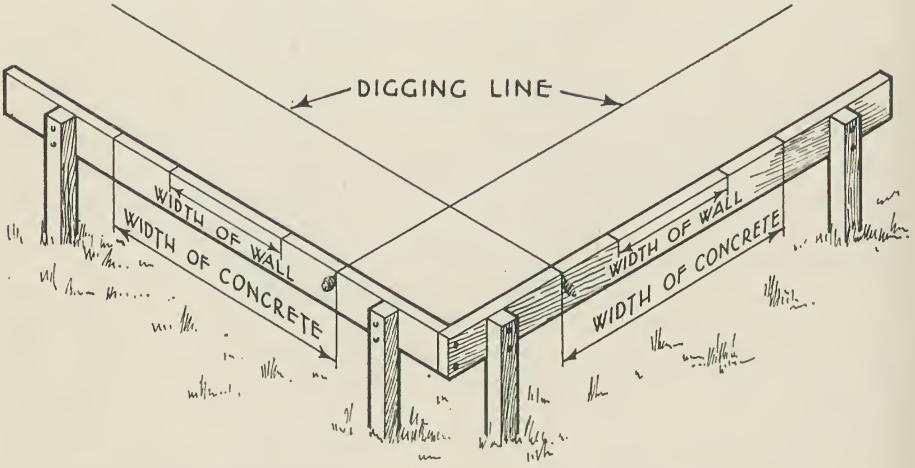


Fig. 2.—PROFILE FOR SETTING OUT EXCAVATIONS AND WALL FOUNDATIONS

creosoted timber the same width as the partition block, a sub-frame into which galvanised cramps can be screwed, giving a strong fixing for the partition. The door lining is fixed to the inside of the sub-frame (see Fig. 4A).

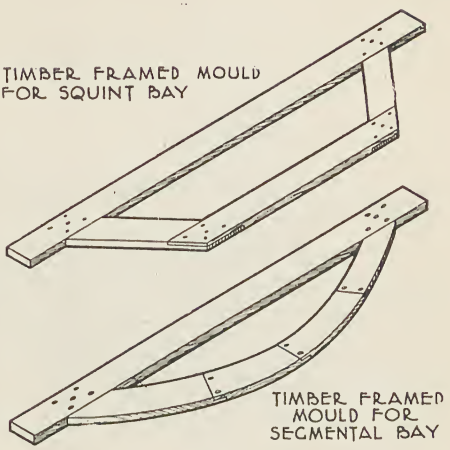


Fig. 3.—TIMBER-FRAMED MOULDS FOR SETTING OUT PROJECTIONS FROM MAIN WALLS

Dead Man

This is a temporary erection of brickwork, usually in the form of a 4½-in. or 9-in. pier, built upright, and each course to the correct height of the brickwork in the building. It saves a considerable amount of levelling out from the quoin brick, and the straightening up of the face of the brickwork with the straight-edge.

Tingle

The tingle is used on long walls, in order to counteract the sagging of the line. A position usually as near central as possible is chosen, and the brickwork kept to gauge and made vertically upright, so that the line can be anchored or tingled at this point. The tingle is made of metal or a looped piece of string or line, and it is held in position with a dab of mortar and weighted down further with a brickbat. For example, see Fig. 4B.

Racking Back, Toothing, and Indents

Brickwork in buildings should progress equally in height over the entire site, and no portion should rise more than 5 ft. 6 in. at any time above the other. Where this is impossible, the brickwork has to be arranged so that the bond of the wall will be effected in the strongest way when the remaining part of the wall is later built. Corners are first erected at the extremities of walls, and the remaining portion between is made linable to the angles. To enable the brickwork to be continued from the corners,

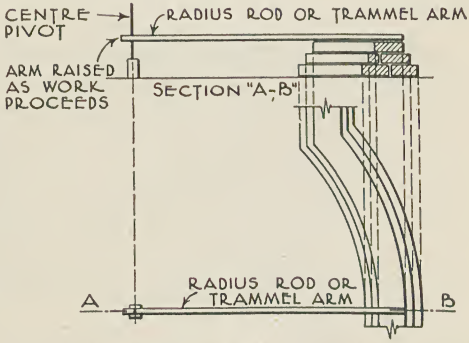


Fig 3A.—SETTING OUT SEGMENTAL BAY WITH TRAMMEL

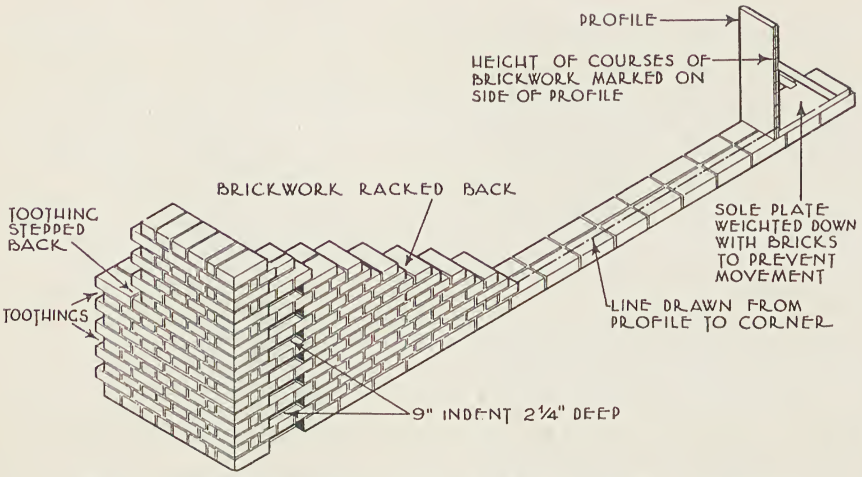


Fig. 4.—DETAIL OF TOOTHINGS, RACKING BACK, INDENTS, AND PROFILE

it is sometimes stepped back on each course. This receding must follow the bond of the wall, and is called *racking back*. For example see Fig. 4.

Toothings

These are recesses formed alternately in the width of the wall to enable a further portion to be built at a later date. The recesses are usually $2\frac{1}{4}$ in. deep, and made the full width of the wall. Toothings should not continue vertically for more than 3 ft., and when the adjoining brickwork is being built into them, great care must be taken to see that the mortar is rammed in tightly around the toothings. When forming toothings the craftsman, on completing his job, should clean out any surplus mortar that has accumulated on the under side of the toothings (see Fig. 4).

Indents

Recesses are formed in walls and partitions in which to bond an adjoining wall. If brick walls are to be built, an indent $2\frac{1}{4}$ in. deep, by the width of the wall, is formed in every alternate course. For partition blocks, the indent must be recessed at least $4\frac{1}{2}$ in. deep, by the width and depth of the partition blocks. An indent is made for every alternate course. Where indents are taken up to a considerable height, a strip of galvanised hoop iron is built into each $4\frac{1}{2}$-in. width of wall every six to eight courses apart, and at least 3 ft. must project to be built into the adjoining wall when the job is completed (see Fig. 4).

Hoop-iron Bond

Brick walls have a stronger tie or bond in their widths than in the length of the walls. In order to strengthen the longitudinal tie, hoop-

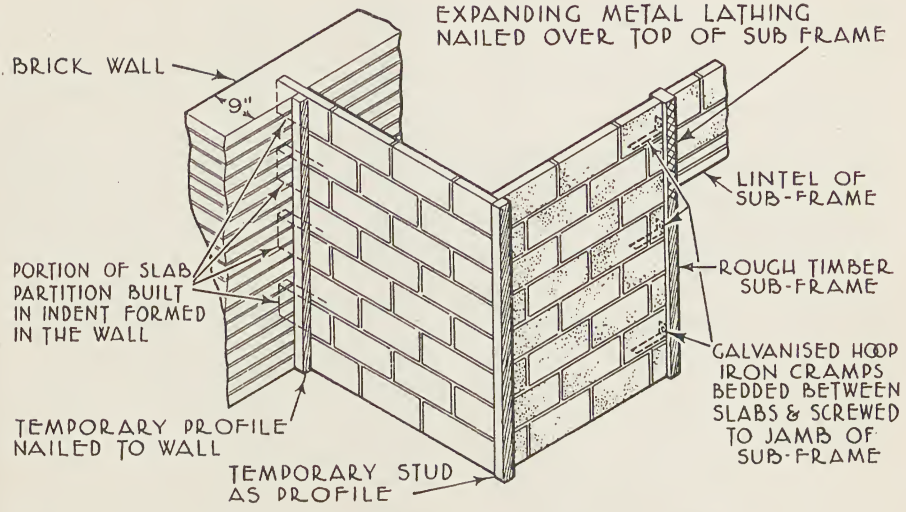


Fig. 4A.—DETAIL OF SLAB PARTITION AND PROFILES

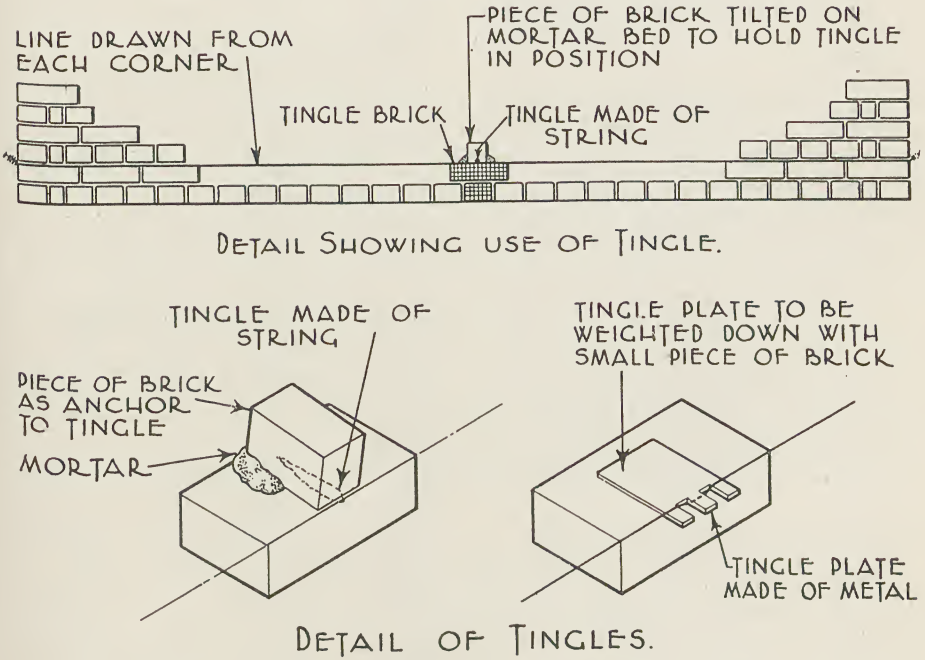


Fig. 4B.—TINGLES AND THEIR USE

iron or expanding metal is built in the wall between the courses of brickwork at intervals of six to eight courses.

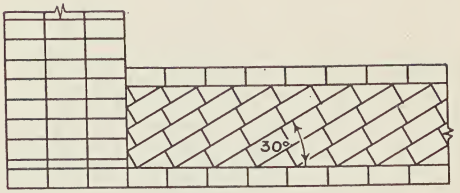
Diagonal and Herringbone Bond

Wide walls are strengthened longitudinally by the use of diagonal or herringbone bonds (see Fig. 5). With the former, the bricks laid in the middle of the wall are placed in a diagonal position, at the angle of 30° to the face of the wall. This course is used at intervals of every 2 ft. in the height of the wall, and is best suited for walls up to 2 ft. 3 in. in width. The direction of the diagonal or raking bond is changed in each course to further strengthen the bond of the wall.

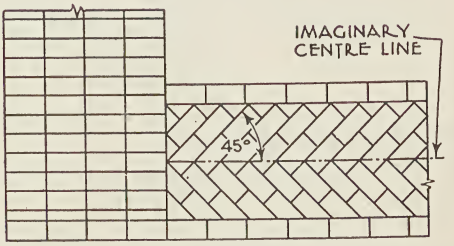
Where possible the diagonal lacing course is placed in a stretching course.

The herringbone arrangement is used in the middle of walls over 2 ft. 3 in. in width. It is best placed in a stretching course, and also used at intervals of 2 ft. in the height of the wall. The herringbone filling is set out along an imaginary centre line in the length of the wall, and the direction of the herringbone is reversed in every course.

Herringbone bond is also used as a decorative feature in panels enclosed with timber framing or purpose-made moulded bricks (see Fig. 6).

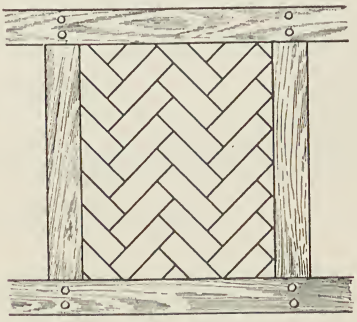


PLAN OF DIAGONAL BOND IN WALL 2'-3" WIDE.

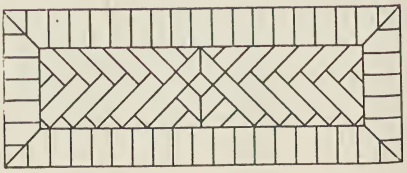


PLAN OF HERRING BONE BOND IN WALL 3'-0" WIDE.

Fig. 5.—DETAILS OF DIAGONAL AND HERRINGBONE BOND



PANEL FRAMED WITH TIMBER.

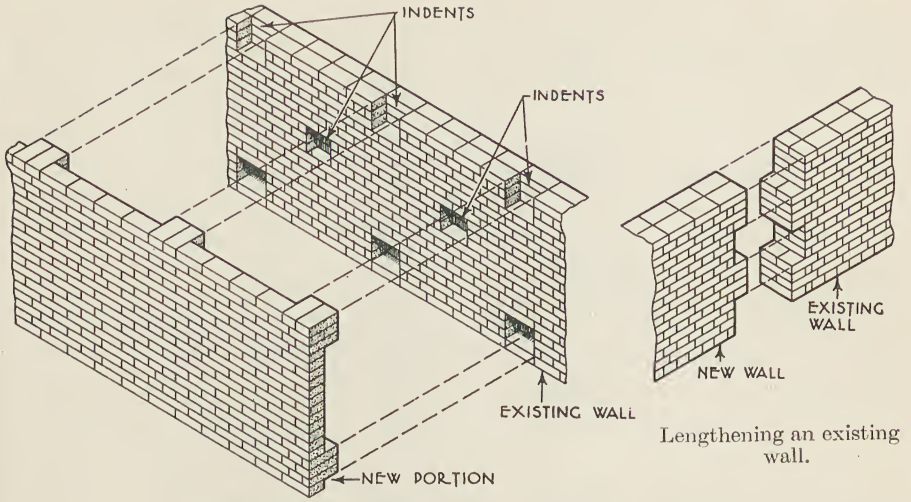


ARRANGEMENT FOR A PANEL OR FRIEZE

Fig. 6.—HERRINGBONE BOND AS A DECORATIVE FEATURE TO BUILDINGS

Bonding New Brickwork to Old

The face of the old wall must be well hacked, and any limewash or distemper completely removed. Bond holes should be cut in the old wall about 3 ft. apart, and are best



Thickening an existing wall.

Lengthening an existing wall.

Fig. 7.—BLOCK BONDING

spaced out diagonally. The condition of the existing wall must be taken into account for the size of the bond hole, but it must be at least 4½ in. wide, 3 in. high, and 4½ in. deep. For example, see Fig. 7.

Lengthening Walls

Walls can be extended in length by cutting out an alternate indent through the width, but if the condition of the wall is such that it will not stand the cutting out of every alternate course, the work will have to be block bonded ; with this a projection and sinking of a specified number of courses, usually three or four, are formed by cutting the wall, and the new work built into the recesses and against the projections (see Fig. 7).

POINTING

The finish to the joints in brickwork is carried out in various styles, and the process is termed pointing. Owing to the difficulty of maintaining a consistent colour throughout the whole of the walls of a building, it is usual to rake out the mortar joints to a depth of at least half an inch, and brush off the work with a stiff broom as the walls are built.

Weather-joint Pointing

When pointing operations are to commence, the walls must be scrubbed down with a hard brush and plenty of clean water. Weather-joint pointing is no doubt the best to resist the weather ; the materials used are composed of ordinary Portland or white cement, and if other colours are specified there are a number of reputable manufacturers who are able

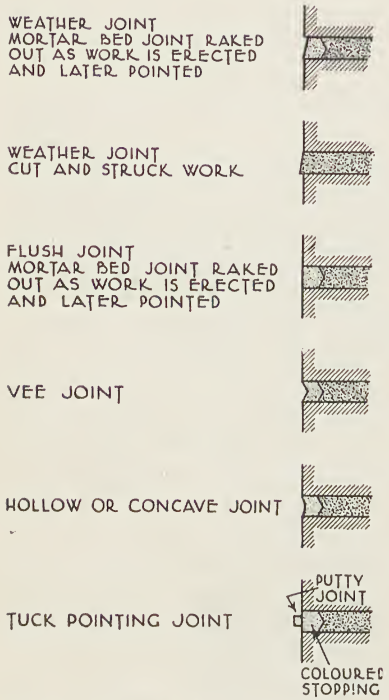


Fig. 8.—VARIOUS METHODS OF POINTING

to supply cements of almost any colour. Washed sand should be used as an aggregate, and the proportions should not be more than one part of cement to three of sand. Care should be taken to select a sand that is best in colour to suit the pointing required, and a sample should be obtained from the merchant supplying the sand. Sand is usually washed on the job ; it is placed in a fine sieve, and the same suspended, but not totally submerged, in a tank or butt of water, and the sieve is swirled round and round. The fine sand required is washed through the bottom of the sieve into the tank, and the large residue left in the sieve is disposed of on the ballast heap. An example of weather-joint pointing will be seen in Fig. 8, and it must be noted that the vertical joints are first filled in and the ragged edge cut off with either the frenchman, a knife-like tool seen in Fig. 9, or with the small pointing trowel used for the vertical joints, and known in the trade as a dotter.

As the vertical joints or dots are placed in position, the excrescence at the top and bottom of the joint that finds its way into the horizontal bed joints is flattened or tucked in to prevent any interruption in the continuance of the bed joints when they are later pointed. A portion of the wall should be covered with dots, cutting-off completed, and then the horizontal bed joints are pointed.

For all kinds of pointing other than tuck pointing, a small flat board with a handle attached, called a hawk, is used to hold the material, in order that it can be picked up on the trowel to be placed into the open joints.

The bed-jointing trowel is larger than the dotting trowel, and care must be taken not to iron the joint in too deeply at the top ; it should be nearly flush with the bottom arris of the brick above. With red or dark-coloured bricks the greatest of care must be taken to ensure that the ragged bottom edge, which is finally cut straight with either a pointing trowel or a frenchman, does not overlap the face of the brick below. A straight-edge with one edge bevelled, and pieces of wood or cork nailed on the face each end, is held against the wall with the top of the rule level with the bottom of the intended finished joint. The frenchman is drawn along the top of the pointing-rule, cutting off the surplus material. The

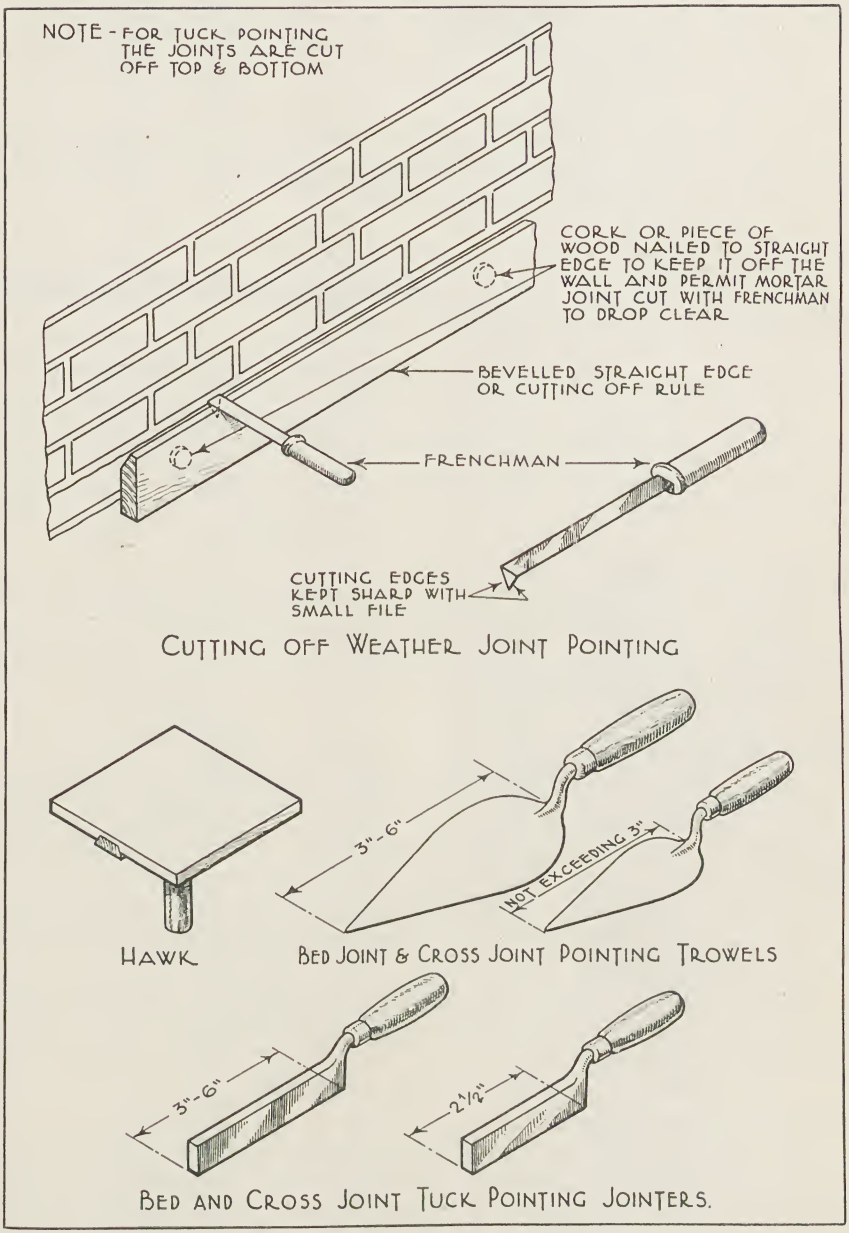


Fig. 9.—POINTING, AND POINTING TOOLS

wall should later be brushed lightly. The cutting edges of the frenchman require to be sharpened from time to time, and a small file should be carried for the purpose (see Fig. 9).

Flush Joint

Flush pointing is very much in vogue at the present time; the joints are pointed full or flush, and the finished effect is produced by drawing either a piece of wood or sacking along the joints.

Hollow or V-shaped Joints

Hollow or V-shaped joints are formed with special jointing tools made to the shape of the required finished joint.

Striking up Joints for Internal Work, where Walls Are Not Plastered

The walls are frequently pointed as they are built, and the pointing is the same as the weather joint, save that the horizontal or bed joints are inverted. The work should be kept as neat as possible, as the ragged edges are not cut off.

Cut and Struck Work

This is carried out when the work is being erected, and can be used for internal or external work. The mortar bed is weathered off to a slightly less pitch than that for the ordinary weather joint, and the joints are cut off with the brick trowel.

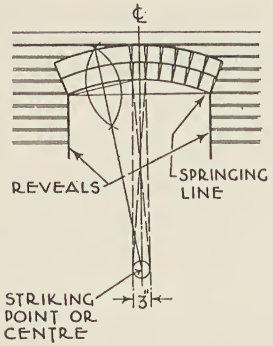
Tuck Pointing

This is mainly used in renovation work, and consists of raking out the old mortar joints, colouring the work, and filling the joints with coloured stopping to produce a monolithic appearance. While the stopping is a little damp, the courses are gauged up the wall and the horizontal lime putty joints pointed first. The putty is placed on the pointing-rule, and it is held up to the gauged marks, and the material is taken off the rule with a tuck-pointing jointer.

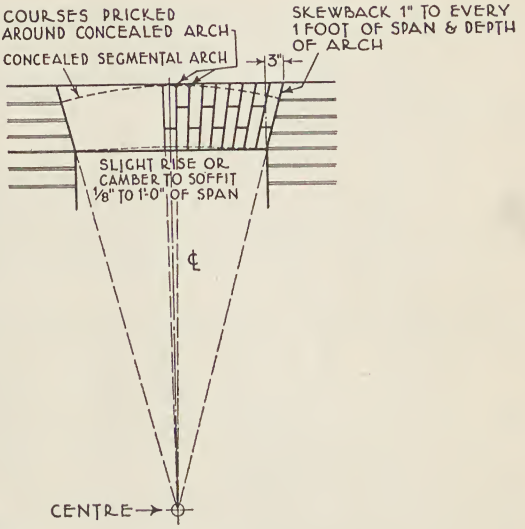
The material, being very fat lime, easily spreads; the joints are cut off top and bottom. The vertical joints are afterwards filled in and cut off as before (see Fig. 8).

Pointing Glazed Brickwork

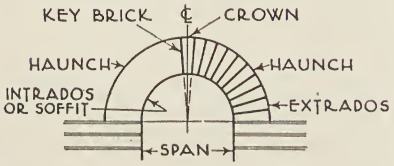
The brickwork should be raked out as the work is built, and when commencing to point the work, the walls should be thoroughly cleaned down with water. Neat cement mortar is used for the pointing material, and this can be applied in a slurry over the joints, cleaned off with a rubber squeegee, and the joints ironed in with a pointing trowel, and finally the face of the wall wiped over lightly with a rag. Another



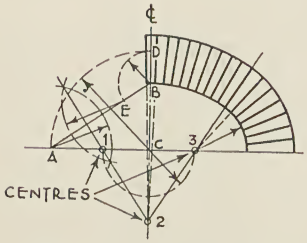
Rough or plain segmental arch.



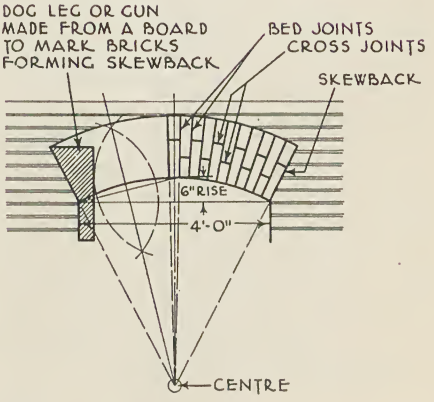
Camber arch.



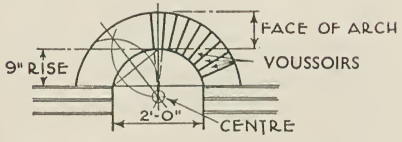
Semicircular arch.



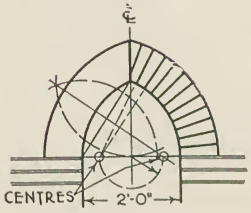
Three-centred semi-elliptical arch. (Span 3 ft. Rise 1 ft.) From centre line, set out span and rise. Connect A B. Mark distance A C up centre line to D. Mark distance B D on diagonal line A B. Bisect A E. Line through arcs gives centres 1 and 2.



Segmental arch.



Scheme arch.



Drop arch.

Fig. 10.—TYPES OF ARCHES AND METHODS OF SETTING OUT

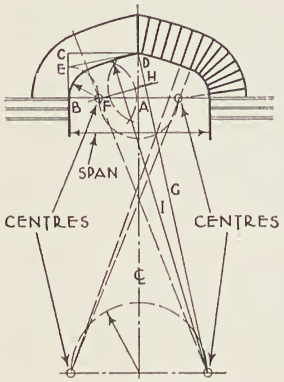


Fig. 10A.—TUDOR ARCH

Erect centre line A D. Set out span and rise. Complete rectangle A B C D. Two-thirds B C, and connect E to D. Square line G from E D. Measure B E to F, and same distance from D to H. Draw line F H and bisect. Where bisecting line I intersects line G is the centre for top of arch, F is centre for lower portion of arch.

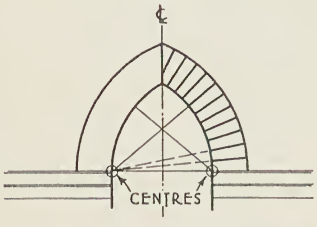


Fig. 10B.—EQUILATERAL ARCH

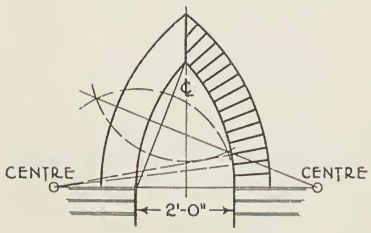


Fig. 10C.—LANCET ARCH

method is to point the walls with neat cement, using the same method as that for weather-joint pointing, cleaning off as before described.

ARCHES

The arch is used to span openings, and to transmit thrusts from above to the adjoining piers forming abutments. It can be constructed of either brick or tile.

Rough or Plain Arches

This type is constructed of ordinary building bricks without being cut, the bed joints between them being V-shape according to the type of arch being constructed.

Gauged Arches

Rough Axed Arch.—For this work bricks are reduced to a definite taper, and a full-sized detail of the arch must be prepared to obtain the necessary templates required for cutting the bricks. The thickness of the bed joints varies from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in thickness.

Cut and Rubbed Arches.—A detail and template are required, and special bricks called rubbers are made for this class of work. Their texture is of such a nature that they can be cut with a wire saw and rubbed to the shapes required. A fine lime putty or neat cement joint is usual for bedding the bricks. A joggle is formed in each side of the voussoirs or tapered bricks, and is afterwards filled with cement grout to key the whole of the arch together.

Making the Template for a Gauged Arch

A full-sized detail of the right-hand side of the arch, including the whole of the key, must be prepared. The shape is first drawn and the courses pricked around the outside or extrados of the arch, each course being equal, the key or central brick being centred exactly on each side of the centre line. A face mould or tem-

plate is made from the shape of the key brick, and this must be traversed over the face of the arch to check its definite proportions. For examples of setting out various kinds of arches, and terms, see Fig. 10.

The temporary timber centering for arches forms the subject of a separate article.

CRAFTSMANSHIP

Bricklaying produces hardy men providing due care is taken to keep dry and warm in wet weather, and guard off a possible attack of rheumatism.

Training for the craft is best commenced at a youthful age, as the mind and body both mould themselves more easily to create a lithe, supple, and clear-thinking individual.

It is often asked if a man over 21 can learn to lay bricks. This depends upon the person concerned, the extent of his interest, the amount of energy spent in seeking the necessary knowledge, and finally a tenacious spirit not to give up when one's endeavours seem to be thwarted in all directions. Before the War it was usual for youths to enter the trade after having served an apprenticeship of five to seven years' duration. Since the War, however, many firms have given up the practice of taking on apprentices, and many lads and young men have had to rely on the influence of some more experienced craftsman to get them a job until they were competent enough to strike out for themselves as an improver bricklayer. Unfortunately, with this system the knowledge of the craft imparted to the improver by the much more experienced craftsman is very little, as the speed of the present-day jobs does not permit time for any instruction. Fortunately, however, in London and most of the large provincial towns, the education authorities have instituted trade classes whereby the budding craftsman can obtain the theoretical and the complete practical knowledge of his craft. Failing this, there are very few small towns which do not possess a lending library, where one can obtain the most up-to-date information in book form about his trade.

Tools Used for Brickwork

In purchasing a kit of tools the craftsman should choose those whose makers guarantee their goods, as often a cheap tool is the most expensive in the end.

The Brick Trowel

This is composed of the blade, a cranked piece known as the *shank*, and the extremity buried in the handle called the *tang*. The wooden handle has a *steel ferrule* around the opening to receive the tang. Some makes have the tang taken through the handle and terminated with a washer-like plate on the end. When trowel handles become loose they

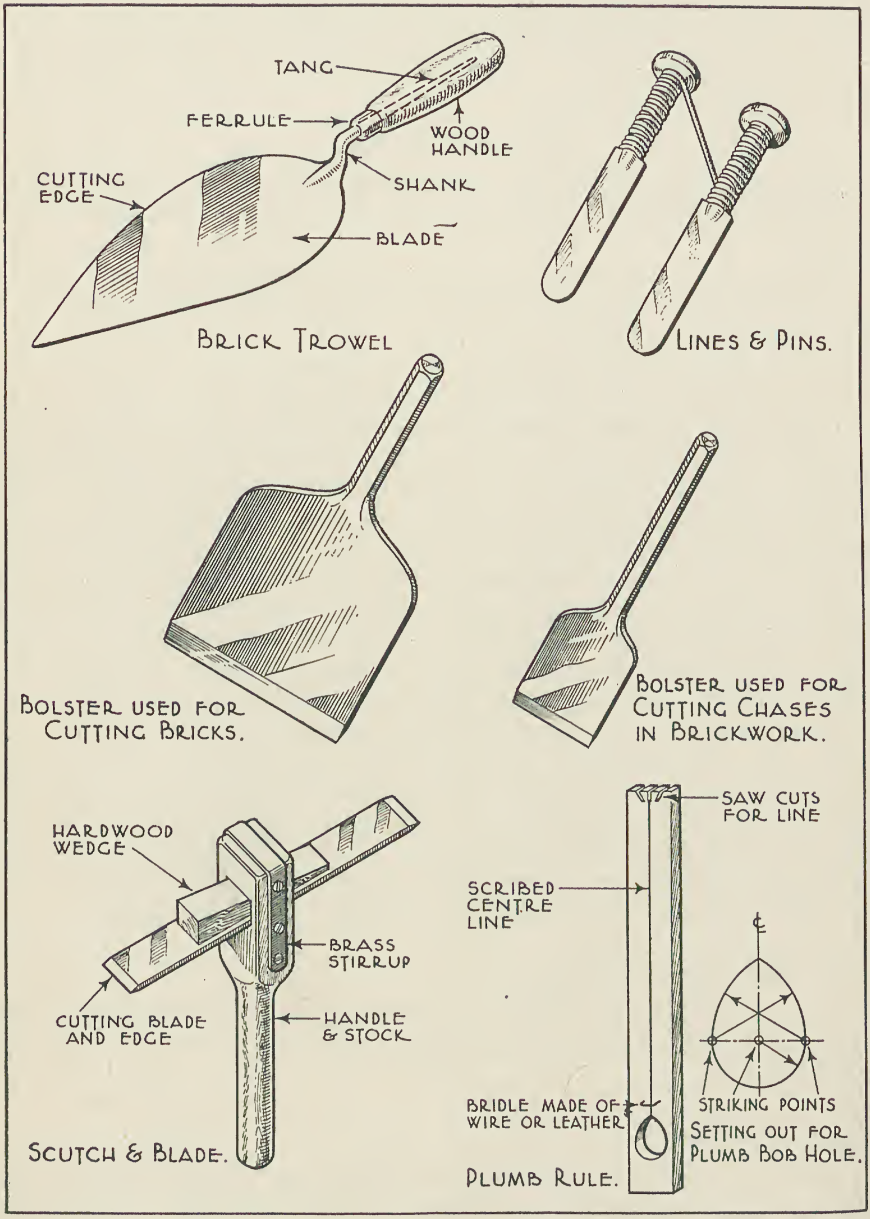


Fig. 11.—TOOLS USED BY THE BRICKLAYER

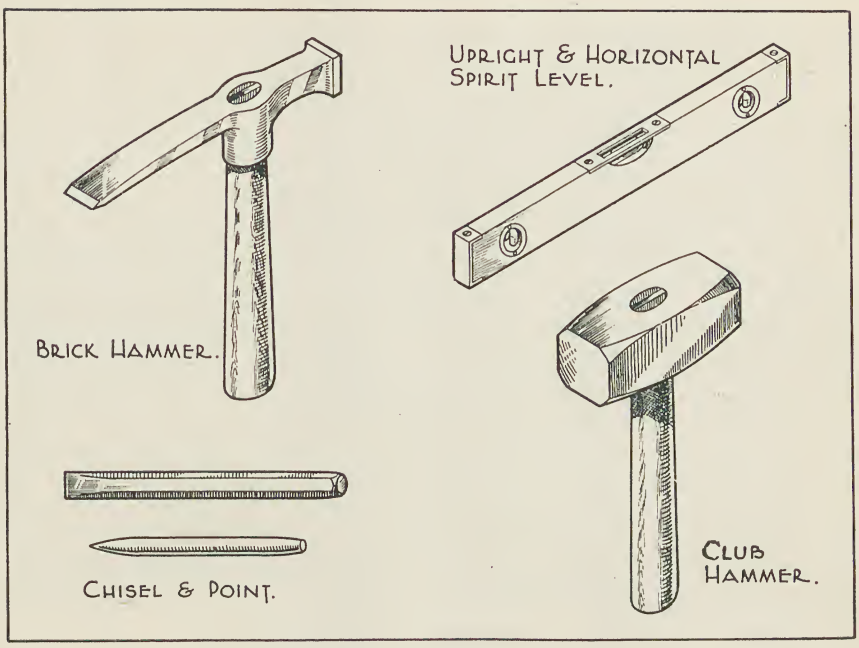


Fig. 12.—MORE TOOLS USED BY THE BRICKLAYER

can be firmly replaced by slightly heating the tang and placing the shredded exterior of a golf ball into the socket, and replacing the tang by gently tapping it into position. Brick trowels are made in various sizes, and it may be noted that a very large trowel, although the envy of most young operatives, is best used only for brickwork where the mortar is either a gauged mortar of lime and small quantity of Portland cement, or simply lime and sand. When purchasing a brick trowel the craftsman should handle the tool to see that the lift is suitable. The lift is the angle that the handle is inclined from the blade.

Club Hammer

This consists of a rectangular, steel, case-hardened head with an ash shaft, varying from 8 in. to 12 in. long. It is used in conjunction with most brickwork cutting tools, and is made in weights varying from 2 lb. to 5 lb.

Bolster

This is a broad-bladed chisel whose width should not be less than 4 in. It is used for cutting bricks to their required lengths. Smaller-width tools are used to cut pipe chases into walls.

Fig. 13.—BRICKLAYING—SPREADING MORTAR

Fig. 14.—REMOVING SURPLUS MORTAR

Lines and Line Pins

Bricklayers depend mainly upon lines to govern the straightness of the brickwork, and they are wound around steel line pins, which are broad-bladed skewers with a large head.

The Scutch

The scutch consists of a steel blade held into a slotted handle or stock with a hardwood wedge. It is an axe-like tool, and is used to further smooth the rugged surfaces of cut bricks.

Brick Hammer

This tool is used for firework, to tap bricks into position, and also for cutting away irregularities on the surface of cut bricks.

Fig. 15.—MORTAR SPREAD READY TO BED NEXT ROW OF BRICKS

The Plumb-rule

This is best made from a piece of straight-grained yellow pine 4 ft. 6 in. to 5 ft. long, by 4 in. wide and $\frac{3}{4}$ in. thick. The sides must be perfectly straight and parallel. A hole to permit the lead plumb-bob to swing is made at least 6 in. up from the bottom. A centre line is cut or gauged into one face of the rule from the top of the bob hole to the top of the rule, and must be parallel with the sides. Saw-cuts are made at the top of the rule into which can be wound a line on which to suspend the plumb-bob. A piece of cord or wire is fixed into the plumb-rule just above the hole, and is called a bridle. It prevents the bob from swinging too far off the plumb-rule.

Fig. 16 (*above*). — PLUMBING THE WORK

from behind, and in building the walls a special-made battering plumb-rule is used.

Level Straight-edge

This tool is very popular to-day, in preference to the plumb-rule. It is made of mahogany, oak, or teak, and has spirit-level tubes placed for vertical and horizontal use. The best type has adjust-

The plumb-rule is used to adjust the corners of buildings or other parts of the building, and prove them to be vertically upright. When brickwork is leaning over at the top it is said to be *overhanging*, and when lying back it is said to be *battering*. Retaining walls are frequently built on the batter to offer greater resistance to the pressure placed upon them

Fig. 17 (*below*).—CUTTING BRICK

Fig. 18.—TERRA-COTTA AIR BRICK IN POSITION

Fig. 19.—LEVELLING THE WORK

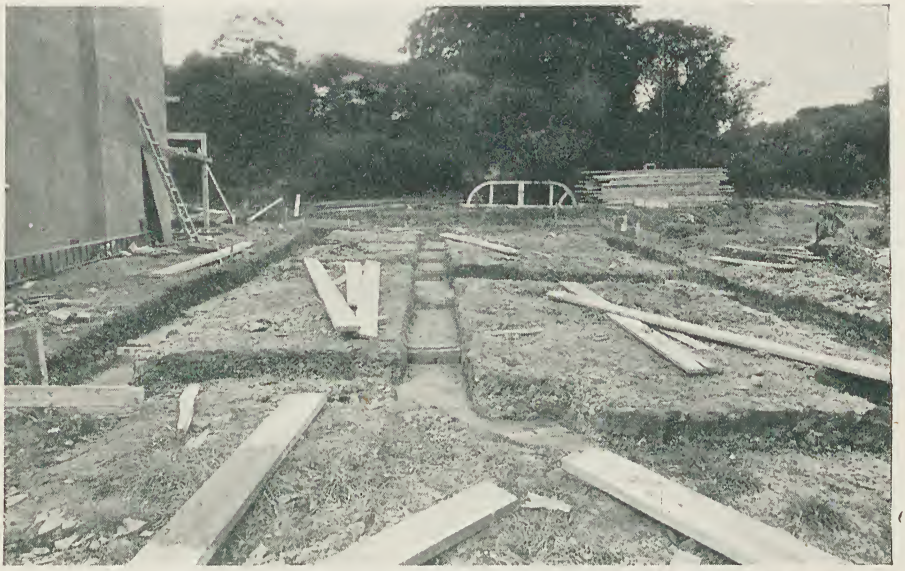


Fig. 20.—CONCRETE FOUNDATIONS, SHOWING STEPS TO CONFORM TO FALL OF GROUND

The profiles used for setting out excavations and wall foundations will be seen in position.

Fig. 21.—PLAN VIEW SHOWING CONCRETE FOUNDATIONS

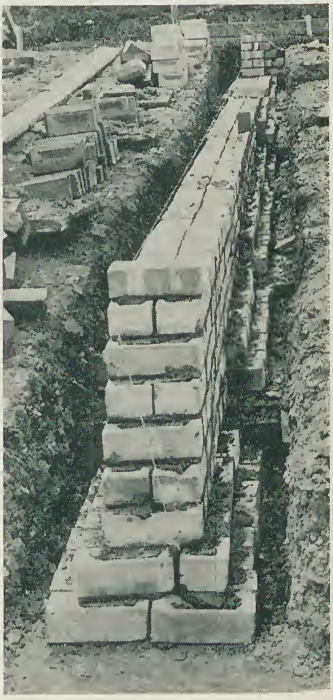


Fig. 22.—STEP FOOTINGS ON CONCRETE

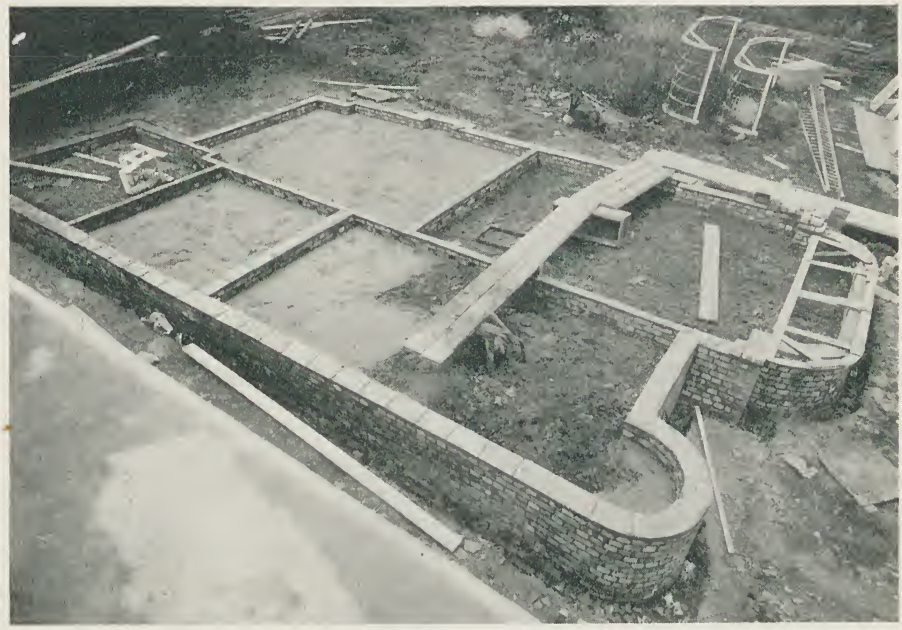


Fig. 23.—PLAN VIEW SHOWING SLATE DAMP-COURSE AND OVER-SITE CONCRETE

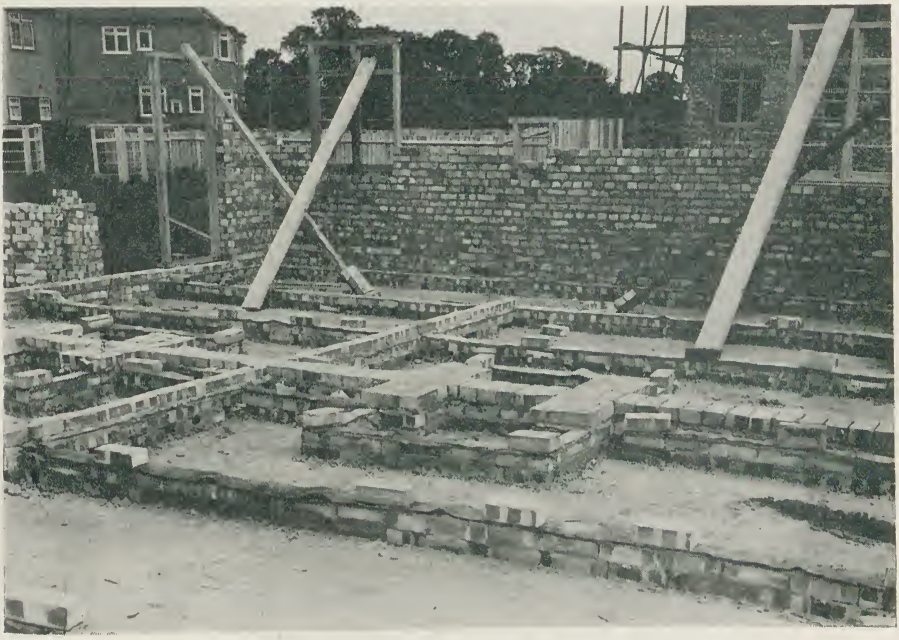


Fig. 24.—GENERAL VIEW OF BITUMINOUS DAMP-COURSE

Fig. 25 (*right*).—DOOR FRAME BRACED READY FOR BUILDING IN

This shows also the bituminous damp-course.

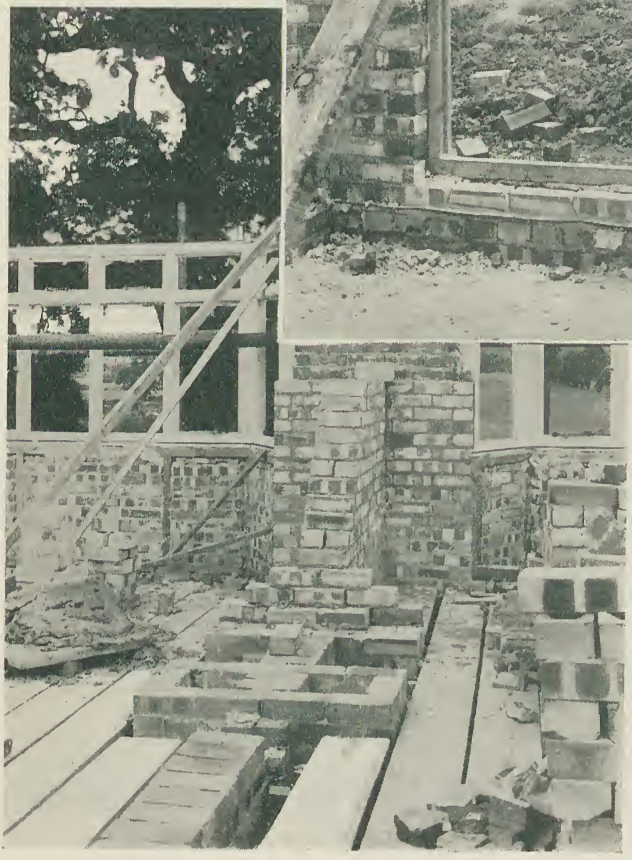


Fig. 26.—FIRST-FLOOR DETAIL OF PARTY WALL, SHOWING FLUES

able tubes, as owing to the numerous amount of knocks they receive the level tubes very soon become out of truth. In order to preserve the wood, the level should be oiled with linseed oil once a week.

Chisels and Points

These are required for cutting bricks and brickwork; the point can be used to advantage where concrete is to be cut away. They vary in length and size; for wall tiling a very small tool will suffice, while for general purposes a chisel 12 in. long should always be carried.

Cutting away is considered to be a hard and laborious task, but much depends upon the type of bricks, mortar, and construction of the work to be removed. If a large aperture is required, it is best to cut back 4½ in. from the face of the wall in the top or bottom of the proposed hole, and further extend this to the entire width of the hole. It is then possible to burst up the courses above or below as required in order to open the chase to about 1 ft. in depth. Further 4½-in. thicknesses in the interior of the width of the wall can be cut away as before, until the entire width has been penetrated. To extend the hole, free the extreme ends and endeavour to lever or cut up the intermediate brickwork. Cutting away for iron brackets, bolts, and other fittings should be as neat as possible, and the chisels for this purpose should be kept with good sharp edges. The interior of the hole should be watered before the fitting is placed into position to be fixed. A strong cement mortar must be rammed into the wall around the fitting, which should be temporarily held into position.

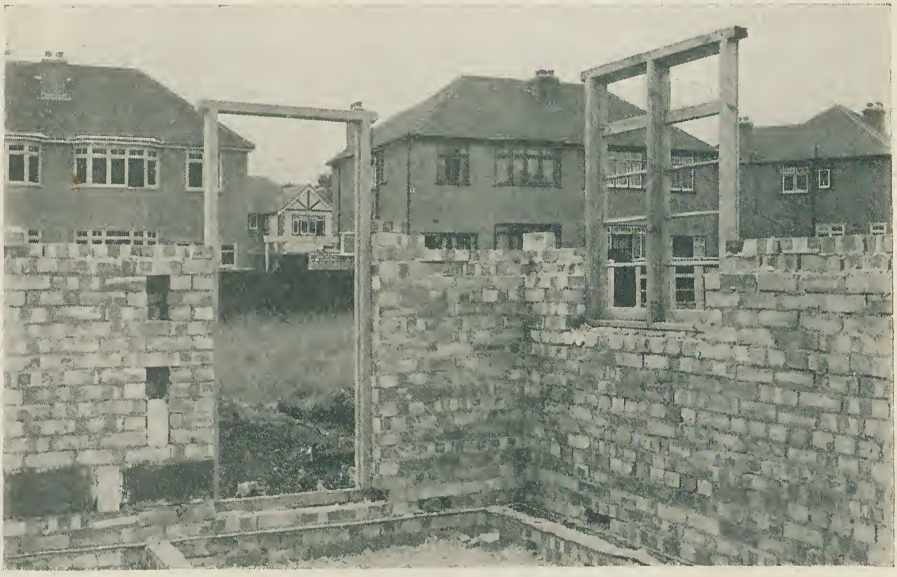


Fig. 27.—WINDOW AND DOOR FRAMES BUILT IN DURING PROGRESS

Fig. 28.—VENTILATION HOLES AND DAMP-COURSE UNDER FLOORS

Measuring-rules

The best-sized rule is the 3-ft. folding box rule, for setting out and general purposes. For the scaffold and cutting shed a brass or steel 2-ft. rule is best, as these can be left on the scaffold and be walked upon without any damage to them.

QUESTIONS AND ANSWERS

What means are adopted to prevent Slab Partition Walls from Buckling while being erected?

Temporary timbers or profiles are erected at the angles or in the middle of the walls. The slabs are built against the temporary stud to give support until the initial set has taken place in the cementing material.

What is a "Dead Man"?

A temporary erection of brickwork, usually in the form of a $4\frac{1}{2}$-in. or 9-in. pier, built upright, each course being to the correct height of the brickwork in the building.

How is the Sagging of the Line counteracted when building Long Walls?

A position usually as near the centre as is possible is chosen, and the brickwork kept to gauge and made vertically upright, so that the line can be anchored or tingled at this point. The tingle is made of metal or a looped piece of string or line, and it is held in position with a dab of mortar and weighed down further with a brickbat.

What are "Toothings"?

These are recesses formed alternately in the width of the wall to enable a further portion to be built at a later date.

What precaution should be adopted when Brickwork is being built into Toothings?

Great care must be taken to see that the mortar is rammed in tightly around the toothings.

What are "Indents"?

Recesses formed in walls and partitions in which to bond an adjoining wall. If brick walls are to be built, an indent $2\frac{1}{4}$ in. deep, by the width of the wall, is formed in every alternate course. For partition blocks, the indent must be recessed at least $4\frac{1}{2}$ in. deep, by the width and depth of the partition blocks.

How is an existing Wall Thickened?

The face of the old wall must be well hacked, and any limewash or distemper completely removed. Bond holes should be cut in the old wall about 3 ft. apart, and are best spaced out diagonally. The condition of the existing wall must be taken into account for the size of the bond hole, but it must be at least $4\frac{1}{2}$ in. wide, 3 in. high, and $4\frac{1}{2}$ in. deep.

How are Walls Lengthened?

By cutting out an alternate indent through the width. If the condition of the wall is such that it will not stand the cutting out of every alternate course, the work will have to be block bonded. With this, a projection and sinking of a specified number of courses, usually three or four, are formed by cutting the wall, and the new work built into the recesses and against the projections.

How is Glazed Brickwork Pointed?

The brickwork should be raked out as the work is built. When commencing to point the work, the walls should be thoroughly cleaned down with water. Neat cement mortar is used for the pointing material, and this is applied in a slurry over the joints, cleaned off with a rubber squeegee, and the joints ironed in with a pointing trowel. The face of the wall is then finally wiped over lightly with a rag.

Another method is to point the walls with neat cement, using the same method as for weather-joint pointing.

PATHS

MATERIALS AND OPERATIONS

Fig. 1.—CONSTRUCTING A CONCRETE APPROACH TO GARAGE
Showing fall to drain, and imitation crazy paving.

THE subject of paths is one allied to building, and particularly to buildings of a domestic character, where some means of access from the main road or street to the front and back doors of a house is absolutely necessary. The subject may be divided into two sections: (1) the garden walk, and (2) the permanently paved path.

GARDEN WALKS

Use of Ashes

The garden walk generally consists of ashes or similar materials, and to maintain in a reasonably good condition needs only to be kept clear from weeds, and occasionally raked over and rolled. The ashes will require renewing from time to time. Unless a foundation of rubble is made, paths of this nature will not be found satisfactory; and particularly if the subsoil happens to be clay, the ashes will soon disappear. So in all

these cases there should be a good bed of broken rubble, 1½-in. gauge, with about 2 in. of ashes spread on top and well rolled. In some of the colliery districts, red ashes, being "spoil" from the pit banks, can be obtained, which give a more cheerful appearance.

Fig. 2.—CONCRETE PATH, SHOWING EXPANSION AT JOINT UNDER HEAT

A strip of asphalte between joints will prevent the above happening.

Crushed Tiles

Better than ashes, however, is a covering of crushed tiles, being the wastage of broken tiles, etc., from a tile works, crushed to a very small gauge, say about ⅜ in.

Gravel

Another covering on a good rubble foundation is gravel, and the rounded pebbles, with their mixture of coarse sand, make an exceedingly attractive path.

Derbyshire Spar or Marble Chippings

White Derbyshire spar, or marble chippings, also make a useful and pleasing path, though the latter are very apt to stain.

Materials for the Edging

Paths of this type require a border or edging, to keep the loose material from being kicked on to the garden beds by the feet of passers-by, and also to keep the soil of the garden beds from encroaching on to the paths. Usually, edging tiles are used, of a more or less ornamental pattern. They should be at least 9 in. in depth, and project 2 in. to 3 in. above the level of the path. Of course, there is a great likelihood, sooner or later, of the tiles getting out of line, or leaning one way or the other. But none of these types of path can be considered as being of a durable character.

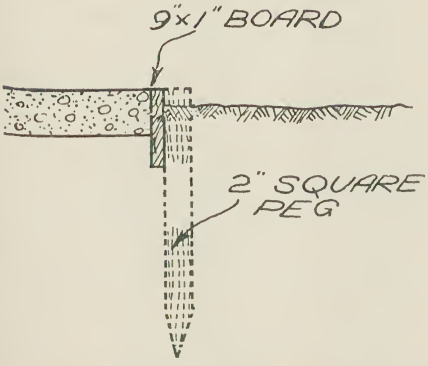


Fig. 3.—WOOD EDGING

PAVED PATHS

The materials for a good, sound, and reliable path are many and varied, such as concrete, asphalte, tar-mac, flags, crazy paving, bricks, and tiles.

Concrete Paths

Assuming that it is properly mixed and finished, concrete is one of the most durable materials, though, at the same time, it is somewhat un-

Fig. 4.—CONCRETE KERB

interesting. In a long length it is desirable to lay it in sections, using a strip of wood as a screed; then, when the screed is removed, filling in with a strip of asphalte, which, being compressible, will allow for expansion. The writer has seen cases, during a very hot summer, where, an ordinary square joint having been left, the concrete has expanded and lifted up nearly six inches (see Fig. 2).

Board Edging for Concrete Path

Concrete needs an edging, if only to keep it from breaking away at the side. The simplest form is a creosoted board, about 9 in. by 1 in., nailed to strong pegs, driven 18 in. or 2 ft. into the ground (Fig. 3). This is economical, but not too satisfactory, as, owing to the shrinkage of the board, the water from the path will dribble between the board and the concrete.

Cast Concrete Kerb

A far better type is a kerb of cast concrete, rounded as in Fig. 4. These kerbs can be obtained in various sizes, such as 7 in. by 3 in. up to 12 in. by 4 in. Usually, they are in 4-ft. lengths, and if occasionally a 2-in. open joint is left, any water collecting on the path will drain away, particularly if the path be slightly cambered, as it should be.

Concrete is very apt to be slippery in frosty weather, but this tendency can be checked by finishing with a slightly rough surface, or by a series of V-shaped grooves cut whilst the concrete is soft.

Coloured Concrete for a Wide Drive

If the path grows to wider proportions, and becomes the drive for a car, it should be at least 8 ft. wide, and then most certainly the appearance, if the drive be of a fair length, becomes somewhat dreary. To obviate this, coloured concrete can be employed as a stripe in the centre, say 3 ft. wide, with 2½ ft. of a natural colour on either side. A dull red, or a sage green, is perhaps the most useful colour. It might be pointed out that if the drive be very long, the stripe may serve to accentuate the length, and make it appear even longer. So it is suggested that in a case of this kind the colour be used in a series of panels, as in Fig. 5.

It is well worth while using a hardening solution for the surface.

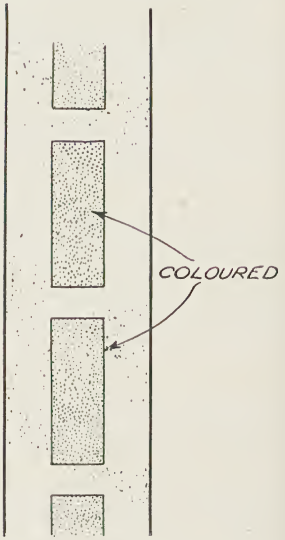


Fig. 5.—PANELS IN CONCRETE DRIVE

Drainage for Drive

Theoretically, the drive should be slightly cambered, but if there be a concrete kerb, as there should be, the water will gather slightly in the gutters so formed. To be entirely satisfactory, a double system of drainage would be necessary. If the main drain happens to be in, or rather under, the drive, as often occurs, the roadway might be slightly hollowed, and the water collected and delivered to the main drain by one or two gullies.

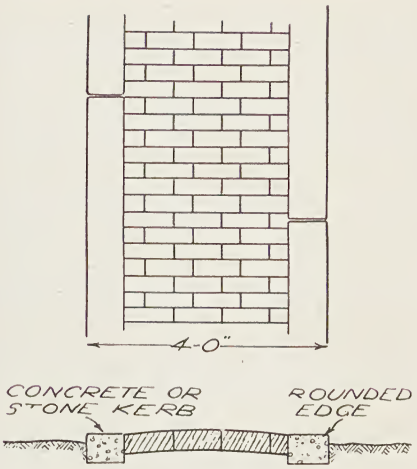


Fig. 6.—Brick path

Asphalte and Tar-mac

For the ordinary garden path, say 3 to 4 ft. wide, concrete, asphalte, and tar-mac are all most serviceable. All require edging, either to protect the sides from breaking away, or to prevent soil, etc., from spreading on to the path. These materials are, however, not in themselves attractive. Another factor to be borne in mind in the selection of materials is the possible desire for alteration in the lay-out of the suburban garden, usually kept in order by the householder. The taking up of a concrete path and clearing away the rubble foundation is a task of some magnitude.

Stone Flags

One of the simplest materials, and probably one of the best for the ordinary path, is the old-fashioned stone flag. Stone flags are rather expensive to obtain in these days, except when the opportunity occurs where old buildings are being demolished. In some towns, where slum clearance is proceeding, the lower floors of many houses are found to be paved with flags, and these have often proved a plentiful source of supply for the garden paths of the newly-built suburbs. Flags are clean and easily laid, and also, if raised about an inch above the general level of the garden beds, need no edging, neither kerb nor edging tiles. Alterations can be easily made.

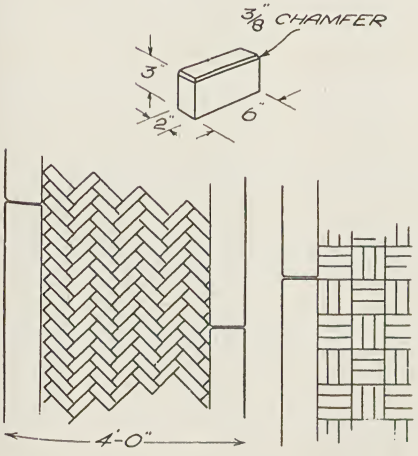


Fig. 7.—Dutch clinker-brick paths

Fig. 8.—METHOD OF MARKING CEMENT SURFACE TO RESEMBLE CRAZY PAVING

Of course in many cases, second-hand flags are worn and pitted, but this is often no detriment, as it helps to take away the newly-made appearance of a garden.

Concrete Flags

Concrete flags, natural colour, $2\frac{1}{2}$ in. to 3 in. thick, also make a first-rate path as far as utility is concerned, but they have a very trim and precise appearance.

Crazy Paving

From squared flags, one naturally turns to crazy paving, so popular to-day. It is more difficult to keep the level, and is best when set upon a concrete bed. Being laid in comparatively small pieces, it should have an edging, as the sides are liable to break away.

One material often used for crazy paving is old "grey slates." These are not, of course, slates at all, but simply thin stone flags that have been employed as slates previously, a type of roofing material that was particularly common in Yorkshire and the Cotswolds. The thickness is usually $1\frac{1}{2}$ in.

Coloured Concrete Crazy Paving

In these days some firms make a speciality of crazy paving in coloured concrete pattern. Naturally the colours are varied, and these paths have a kaleidoscopic effect, though not without their attraction.

It is a matter of individual taste whether the joints in flagged paths, or in crazy paving, should be filled in and pointed. Certainly, from the point of view of cleanliness and neatness this is desirable, but on the other hand, many people prefer to see clumps of moss, stone-crop, etc., growing in the joints. Naturally, concrete flags, being made absolutely square, must have the joints pointed, and the same remark applies to the coloured crazy paving mentioned above.

Red Tiles

Red tiles, either 6 in. or 9 in. square, make a very attractive path, but should always be laid on a concrete bed. They require an edging, whether

laid square or diagonally, but instead of the ordinary type of edging tile, a flat stone kerb can be employed 7 or 9 in. wide, which makes a variety to the finish. It might here be mentioned that whenever this form of kerb is used, the outer angle could be slightly rounded with advantage, as a sharp clean arris is liable to be chipped by gardening tools.

Common Bricks

Ordinary common bricks, when carefully laid, make a really good path, and are very delightful in appearance. They must be laid upon concrete with fine joints (Fig. 6), and slightly cambered, say about ½ in. It is advisable that the joints be grouted in thin mortar. The bricks should be selected of a reasonably uniform colour, and a flat kerb is the best for this type of path.

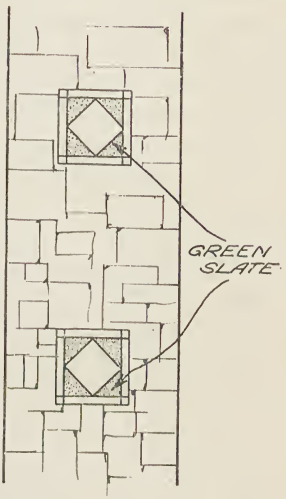


Fig. 6.—PANELS IN WIDE PATH OR TERRACE

Dutch Clinker Brick

One class of material rarely employed in this country for paths is the Dutch clinker brick. These are small bricks, 6 in. by 3 in. by 2 in., and have a slight bevel or chamfer all round. They are of a creamy colour ranging to buff. As seen in Fig. 7, laid herringbone, or indeed in any pattern, they are absolutely "non-slip." This is another of the most attractive forms of a path that can be devised. Fig. 7 shows a path 4 ft. wide, with a stone kerb on each side, and the centre track in these small clinker bricks. Another type of design for the centre is the diaper pattern, i.e. three bricks making a 6-in. square panel; and these panels laid alternately, either diagonally or square.

Terrace Treatment

In many cases, when the path reaches the house it widens out and becomes the terrace. When it is possible to make it 8 or 10 ft. wide it decidedly enhances the appearance of a building. The paving of the terrace certainly gives a fine opportunity to the designer. Obviously concrete is not suitable, and probably the most attractive material for the paving of the terrace is natural flags, squared, but laid irregularly. If the terrace be large enough, a centre panel or series of panels in another material will add to its charm. Red or buff bricks may be used, or a panel of flags (see Fig. 9) in the form of a large flag laid diagonally, the triangular corners being filled in with green slate, and surrounded by a border.

Occasionally the panel can be simply a flower bed.

The careful use of a good green Westmorland slate will much enhance the appearance of the flags. The ordinary flagged path can be enlivened by bands of green slate about 8 in. wide adjoining the kerbs. The writer has seen slates on edge used in panels on a terrace, though one gets the impression that their rough edges will make the panels difficult to keep clean.

In cases where expense has been no object, there may be seen many beautiful examples of the paving of a terrace, such as the pointed star, sun-ray, and other patterns formed with a mixture of materials as flags, bricks, tiles, and slates, all combining to give a very effective result.

The question of whether a path should be straight or curved depends upon the general layout of the garden ; but as this scarcely comes within the province of the builder there is no need to discuss it here ; but as a general rule, in the small garden, the straightest and most direct route from the garden gate to the door is the best.

Use of Steps

The gradients of the path are usually settled by the general slope of the site, though it is desirable to keep the inclination as easy as possible, and if a path must of necessity be steep, a few steps at intervals are much better than a very steep slope. At the same time they will look more attractive with flanking walls.

QUESTIONS AND ANSWERS

How may Board Edging be applied for a Concrete Path ?

A simple form is a creosoted board, about 9 in. by 1 in., nailed to strong pegs driven 18 in. or 2 ft. into the ground.

What are the usual dimensions of Cast Concrete Kerbs ?

Cast concrete kerbs may be obtained in various sizes, such as 7 in. by 3 in. up to 12 in. by 4 in. Usually they are in 4-ft. lengths.

What are Dutch Clinker Bricks ?

Small bricks, 6 in. by 3 in. by 2 in., having a slight bevel chamfer all round.

TIMBER FLOORINGS

MATERIALS AND OPERATIONS

THE difference between a good floor and a bad floor is no more than a matter of care—care in the seasoning and preparation of the timber, and care in regard to the conditions under which it is laid.

It will perhaps be suggested that a factor of prime importance, viz. quality of the timber, has been overlooked—such, however, is not the case, for whereas second-grade timber scientifically dried and well laid under suitable conditions will give a first-class surface, on the other hand, the best graded timber indifferently dried and put down without thought under unsuitable conditions, quickly develops faults.

Timbers in General Use

The variety and choice of wood floorings available in these days give to the architect and principal a scope such as was not afforded before the War. In place of the old conservatism and prejudice there has appeared the desire to obtain the unusual—to have something just a little different. This objective is generously provided against, for during the past few years sentiment has been focused on things Empire, and within the Empire are to be found timbers of a beauty and configuration which equal, if not transcend, those of foreign origin, and which are of proved reliability.

Kiln Drying and Conditioning

The importance of utilising every aid, natural and scientific, to ensure the dryness and condition of hardwood floorings has only recently been fully realised—a realisation, born of much trial and tribulation, brought about partly by the extension of central heating in this country, and partly by the unfortunate fact that hustle is the essence of present-day building contracts. For ordinary joinery purposes it is estimated that hardwoods which have been seasoned at the rate of 18 months per inch of thickness, and softwoods for a rather lesser period, are dry ; but it is not, however, generally appreciated that timber is very susceptible to atmospheric change, and that the moisture content may vary several per cent. during the course of 72 hours. This, obviously, presents a difficulty, for although a flooring manufacturer may legitimately offer his floorings as " dry," i.e. as containing about 9 per cent. to 11 per cent. of

DESCRIPTION AND SPECIFICATION OF VARIOUS TIMBERS IN GENERAL USE FOR FLOORING PURPOSES

	Description	*Comparative prices, taking the No. 100 as index figure*	*Specification of sizes available for floorings in long boards*
AMERICAN PLAIN OAK.	There are many who have a prejudice against American oak, probably because the southern red variety is a poor proposition, but prime northern white American oak makes a really first-class hard-wearing floor.	90	From $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 6 ft. to 16 ft. long (Averaging 9 ft.)
AMERICAN FIGURED OAK.	Ditto.	100	Ditto.
JAPANESE PLAIN OAK.	A good flooring oak but of rather "caney" grain, and probably, therefore, not so durable as other types. Japanese oak is, nevertheless, very largely used.	90	From $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 6 ft. to 14 ft. long (Averaging 8 ft.)
JAPANESE FIGURED OAK.	Ditto. (A flooring with 50 per cent. each of plain and figured Japanese is of excellent appearance and not so ostentatious as a full figured.)	100	Ditto.
AUSTRIAN OAK.	Imported from Slavonia (Jugo-Slavia). There are many types of oak now shipped from Central Europe almost identical in appearance to the Slavonian, but they are of harsher texture. To ensure the finest and best it is necessary to insist upon genuine "Slavonian." Mostly available quartered or half-quartered.	120	From $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 6 ft. to 14 ft. long (Averaging 8 ft.)
RIGA OAK. VOLHYNIAN OAK. ODESSA OAK.	South Russian oaks from Volhynia and Minsk forests, shipped through the ports of Riga and Odessa. Almost equal in quality, texture and colour to the genuine "Slavonian," and although cheaper than the Slavonian it is probably quite as good for flooring purposes. Usually sold to contain 25 per cent. figured and 75 per cent. plain.	95	From $\frac{3}{8}$ in. to $1\frac{1}{4}$ in. thick ,, 3 in. to $4\frac{1}{2}$ in. wide ,, 6 ft. to 14 ft. long (Averaging 8 ft.)
DANZIG OAK. POLISH OAK.	Of a similar nature to the Riga, Volhynian and Odessa oaks, but less mild in texture, and therefore less reliable.	90	From $\frac{3}{8}$ in. to $1\frac{1}{4}$ in. thick ,, 3 in. to $4\frac{1}{2}$ in. wide ,, 6 ft. to 12 ft. long (Averaging 8 ft.)
PITCH PINE.	Pitch pine flooring gives a fine surface at a reasonable cost, most suitable for schools, public institutions, dancing floors, etc. The grading of pitch pine is confusing, i.e. "first-quality Rio" is somewhat knotty, and for entire freedom from knots "EXTRA PRIME PENSACOLA" should be specified. "First-quality Rio." "EXTRA PRIME PENSACOLA."	 65 75	From $\frac{3}{8}$ in. to $1\frac{1}{4}$ in. thick ,, 3 in. to 5 in. wide ,, 10 ft. to 22 ft. long
BAGAC.	A timber of reddish-brown colour, close texture and considerable tensile strength imported from the Philippines. Requires very careful seasoning if used for flooring. Unsatisfactory in thicknesses under 1 in.	90	From 1 in. to $1\frac{1}{2}$ in. thick ,, 4 in. to $4\frac{1}{2}$ in. wide ,, 10 ft. to 22 ft. long (Averaging 12 ft.)

DESCRIPTION AND SPECIFICATION OF VARIOUS TIMBERS IN GENERAL USE FOR FLOORING PURPOSES

	Description	*Comparative prices, taking the No. 100 as index figure*	*Specification of sizes available for floorings in long boards*
	Hardwood Floorings from Empire Sources		
MOULMEIN TEAK. RANGOON TEAK. BURMAH TEAK. (*India.*)	Too well known to require description. Probably unequalled for hospital floorings. Extremely durable and not very liable to splinter.	120	From $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 6 ft. to 16 ft. long (Averaging 9 ft.)
MAHOBORN TEAK. (*East Indies.*)	An excellent substitute for Indian teak, showing a saving in cost of some 25 per cent. Hard wearing and reliable. Of a more reddish colour than the Indian teak, but becomes brown with age.	95	From 1 in. to $1\frac{1}{2}$ in. thick ,, 4 in. to $4\frac{1}{2}$ in. wide ,, 10 ft. to 22 ft. long (Averaging 15 ft.)
MAPLE. (*Canada.*)	Maple as a flooring is often disappointing—not in regard to reliability or durability, for in these directions it is eminently satisfactory—but in regard to appearance. From a small sample of flooring a fine white surface is visualised, whereas in the bulk parcel a percentage of boards will be brown and discoloured, and if perfection is aimed at it can only be attained at the increased cost involved in eliminating this coloured material.		
	Prepared and machined in U.S.A.	55	From 1 in. to $1\frac{1}{4}$ in. thick ,, 4 in. to 5 in. wide ,, 2 ft. to 14 ft. long (Averaging 5 ft.)
	Prepared and machined in Great Britain.	85	From 1 in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 8 ft. to 16 ft. long (Averaging 12 ft.)
TASMANIAN OAK. (*Tasmania.*)	This is actually the EUCALYPTUS tree, but it is imported under the trade term of "Tasmanian oak," for in appearance and colour it is not unlike Southern American oak. Although not particularly dense in texture, it is very tough and makes a good and inexpensive floor.	85	From 1 in. to $1\frac{1}{2}$ in. thick ,, 4 in. to $4\frac{1}{2}$ in. wide ,, 6 ft. to 16 ft. long (Averaging 9 ft.)
AUSTRALIAN SILKY OAK. (*Australia.*)	A handsome decorative wood of light buff colour. When cut on the quarter it shows countless flecks rather similar to those appearing in quarter-cut beech. Of hard, firm texture.	135	From 1 in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 6 ft. to 16 ft. long (Averaging 9 ft.)
INDIAN SILVER GREYWOOD. (*India.*)	Finely streaked with black and brown on grey. Will produce an attractive and quite unusual flooring.	135	From 1 in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 8 ft. to 16 ft. long (Averaging 9 ft.)
NIGERIAN WALNUT (*Nigeria.*)	A timber of biscuit colour carrying a "roey" figure and occasionally marked with black. Nigerian walnut may be polished to shades ranging from a golden yellow to a deep rich brown.	110	From 1 in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 8 ft. to 16 ft. long (Averaging 9 ft.)
GURJUN. (*India.*)	A hard, dense timber of reddish-brown colour.	90	From 1 in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide ,, 10 ft. to 20 ft. long (Averaging 14 ft.)
BRITISH COLUMBIAN PINE.	Different names for the same species of fir. The grade known as "No. 2	45	From $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. thick ,, 3 in. to 5 in. wide

DESCRIPTION AND SPECIFICATION OF VARIOUS TIMBERS IN GENERAL USE FOR FLOORING PURPOSES

	Description	*Comparative prices, taking the No. 100 as index figure*	*Specification of sizes available for floorings in long boards*
OREGON PINE. DOUGLAS FIR.	Clear and Better " is entirely clear of any knots and makes a first-class and very inexpensive flooring. Used largely for public institutions, schools, etc.		From 10 ft. to 24 ft. long (Averaging 14 ft.)
	Softwood Flooring		
DEAL: RED, WHITE.	Imported almost entirely ready prepared for floorings, either with a square tongue and groove, or square-edged. Available in 1st, 2nd and 3rd quality or " Unsorted."		From ½ in. to 1½ in. thick „ 3 in. to 7 in. wide „ 10 ft. to 18 ft. long (Averaging 10 ft.)
	1st quality.	28	
	2nd quality.	23	
	3rd quality.	18	
	" Unsorted."	23	

moisture, by the time they are actually laid, especially if the building is new, or the weather humid, they may have reabsorbed up to 15 per cent. of moisture, and when eventually the radiators are put into use there will be inevitable and serious shrinkage. By way of illustration, the writer has knowledge of a floor laid with long 1¼-in. by 4-in. tongue and groove oak boards, which had definitely been seasoning for 14 years, but these boards very soon " opened " to the extent of ⅛ in. or more at every joint, and for the reason that during two weeks they had been stored in a room where the atmosphere was rather less dry than that in which they were eventually put down.

In a further instance, several hundred squares of Slavonian oak flooring were taken direct from the drying kilns, showing after tests had been made a moisture content ranging from 9 per cent. to 11·2 per cent., and delivered into one of the new London luxury hotels. A month later, in consequence of reports of an alarming shrinkage, further tests were taken, in which it was found that the moisture content of the boards was still between 9 per cent. and 11·2 per cent., thus proving conclusively that in the interim, between their arrival in the building and their being laid, they had picked up considerable moisture from the dampness exuded by the new brick and plaster work, and that this moisture again dispersed immediately central heating was put into operation. How, then, in the face of these circumstances, may a perfect surface be attained ? At the outset, it is obviously necessary to ensure that the timber has been air seasoned for the recognised period according to thickness, and after being machined to the appropriate section it is of great advantage that it should be replaced on sticks for three or four weeks before actual use, for, when fresh surfaces have been exposed to the air during preparation, there is liable to be a certain amount of movement. As to whether the material is, in addition, placed through a drying kiln, is a matter of

opinion and convenience, but, provided it has been previously adequately air seasoned in close storage, and used in the summer months of the year, kilning would appear to serve very little purpose.

Fig. 1.—LAYING BATTEN FLOORING

Ensuring a tight-fitting floor by clamping tongued and grooved board tightly up against its predecessor. The chisel is being used as a lever against an improvised wooden floor cramp.

Arrival on Site

The arrival of the flooring on the site of the work is the crucial point, for by its subsequent treatment will be laid the foundations of either a perfectly finished floor, or one which reflects discredit on all concerned. In an old building the storing of the boards for a few days in the rooms in which they are to be laid will be sufficient to acclimatise them to the existing atmosphere, but no flooring, however carefully seasoned, will prove satisfactory in a new building saturated with moisture unless, for some little time previously, and during the whole process of laying, it has been warmed by central heating or open fires. It may be argued that

Fig. 2.—LAYING BATTEN FLOORING

This shows the angle of the nail for secret nailing. Note how the operator is holding the cramp securely to the board to ensure a perfectly close-fitting joint.

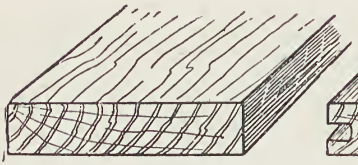


Fig. 3.—SQUARE-EDGED BATTEN FLOORING

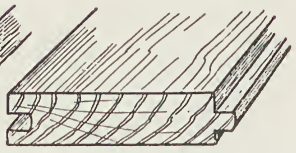


Fig. 4.—SQUARE TONGUE AND GROOVE BATTEN FLOORING

such precautions as these are sometimes impracticable, or, alternatively, that they are inconvenient—what, however, are a few days' inconvenience by comparison with many years of disappointment and irritation?

BATTEN FLOORING AND HOW TO LAY IT

Types of Batten Flooring in Long Lengths

Batten floorings are available normally in thicknesses of ½ in. nominal up to about 1½ in., in widths of from 3 in. up to 5 in., and in lengths running from 4 ft. to 20 ft. They are prepared either square-edged or in a variety of secret-nailed joints, or, further, they are grooved and jointed up with a loose tongue. The smallest satisfactory thickness in a tongued and grooved section is ½ in. nominal.

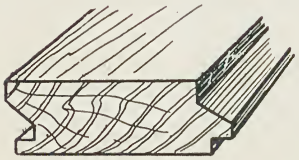


Fig. 5.—PAVADILOS JOINT IN BATTEN FLOORING

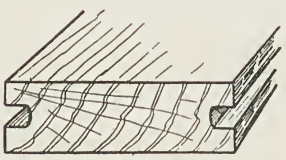


Fig. 6.—JOINT FOR LOOSE TONGUES IN BATTEN FLOORING

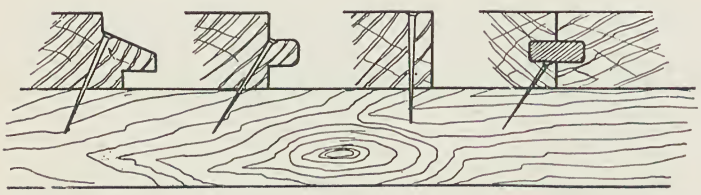


Fig. 7.—METHODS OF NAILING VARIOUS TYPES OF BATTEN FLOORING

The above examples show the various types of secret-nailed floorings and the square-edged flooring.

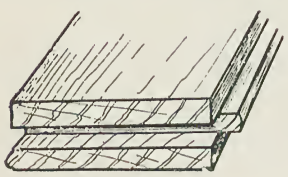


Fig. 8.—BLOCK FLOORING

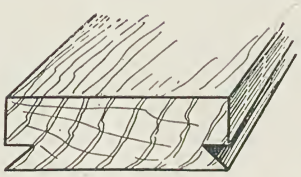


Fig. 9.—ANOTHER TYPE OF BLOCK FLOORING

Foundations of Batten Flooring

These floorings are generally laid over deal joists of 2 in. by 4 in. and upward, spaced from 12 in. to 15 in. apart. Although occasionally they

are put down direct on to a composition of coke breeze, this is not a very satisfactory method, inasmuch as the breeze will not always hold the nails securely, and the whole floor has a tendency to become loose.

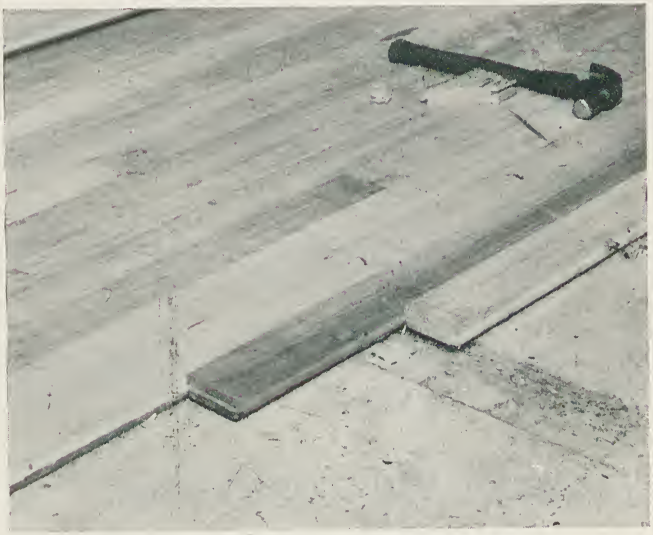


Fig. 10.—FLOORBOARDS WITH ENDS "MATCHED"

A saving in waste is effected by having tongued and grooved ends, inasmuch as the butt joints need not necessarily be made over a joist or fillet sunk in the concrete.

From the point of view of economy in first cost, and also in the cost of laying, the ordinary straightforward tongued and grooved boards are to be recommended. But where expense is a secondary consideration a better and more reliable surface is undoubtedly to be obtained with boards that are grooved on both edges and jointed together with a loose tongue.

How to Lay Batten Floorings

The method of laying these batten floorings is extremely simple. A start is made at one side of the room to be covered, leaving a gap of about ½ in. between the first line of boards and the wall, to allow for any small subsequent movement or expansion. This gap

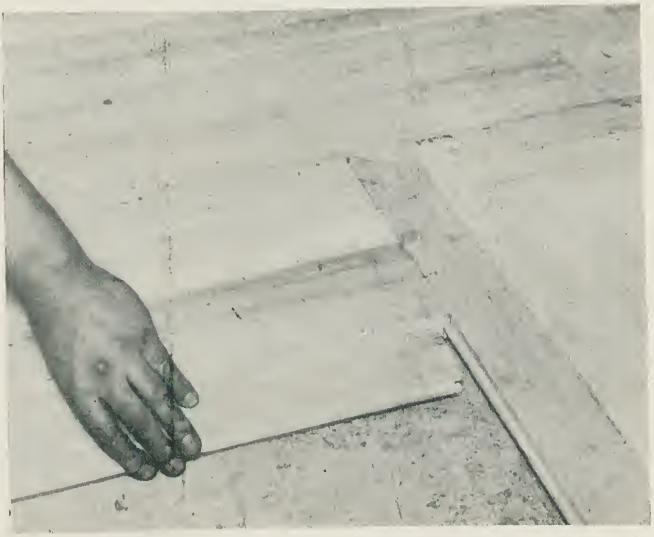


Fig. 11.—BUTT JOINTING TASMANIAN OAK FLOORING TO MITRED FRAME SURROUNDING MARBLE PILLAR

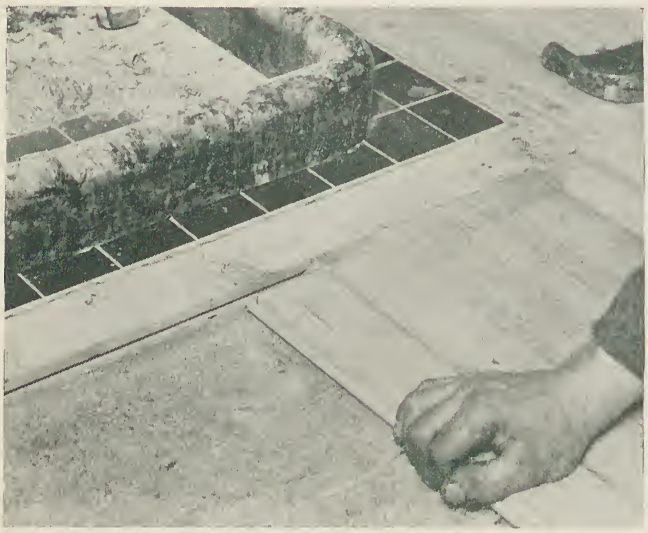


Fig. 12.—FITTING SECRET-NAILED FLOORBOARDS TO HEARTH SURROUND

is, of course, hidden by the skirting. Thereafter it is only a matter of ensuring that each board is tightly cramped up to its predecessor before being nailed. It may be necessary to "ease" the tongues a little with a scraper.

Making Tight-fitting Joints

There are several special flooring cramps on the market, but for the most part these are heavy and unwieldy. Provided the tonguing and grooving of the material has been carefully machined, a perfectly close-fitting joint should be obtained by the use of wooden wedges as levers.

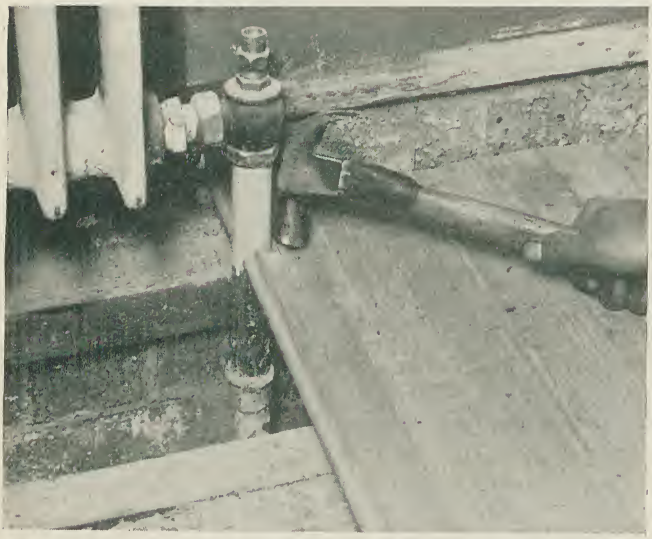


Fig. 13.—THE DANGER SPOT FOR FLOORINGS—THE RADIATOR

Good, well-fitting joints here are essential, as some small shrinkage is almost inevitable.

Nailing the Boards

For secret-nailed floorings of 1 in. nominal thickness, a $1\frac{1}{2}$-in. wrought "rose head" nail should be employed, with proportionately smaller or larger nails for lesser or greater thicknesses. Batten flooring which is grooved on both edges to take a loose tongue is

also nailed in the same way as the ordinary secret-nailed flooring, the nail being driven at an angle of 45° through the lower lip of the groove into the joists, and hammered well home with a punch. The loose tongues, after being glued, are then inserted and the following boards jointed up in exactly the same way as the tongued and grooved flooring. In the case of batten floorings that are simply prepared square-edged, these must, of course, be nailed through the top.

BLOCK FLOORING

Types and Sizes

Block floorings are manufactured either tongued and grooved on both sides and at the ends, or just grooved on both edges. They are available in a variety of sizes, although the most usual and most attractive sizes for ordinary purposes are 12 in. by 3 in. and 9 in. by 3 in. The thicknesses are 1 in., $1\frac{1}{4}$ in. and $1\frac{1}{2}$ in. nominal.

Important.—Foundation of Flooring Must Be Perfectly Dry

Since block floorings are laid in mastic direct on to a concrete foundation, it is essential that the concrete be left smooth by the builder, and also that it is thoroughly dry. Otherwise the blocks will absorb dampness, swell, and, as something must give, many will be squeezed upwards, leaving a very irregular finished surface.

Preparing Surface for the Blocks

At the outset, with a specially prepared varnish, paint over the surface of the concrete. The effect will be to secure any loose concrete dust ; if this is not done the mastic will not adhere firmly.

Laying the Blocks

There are several good brands of mastic, which is a solidified tar substance. The mastic must be heated until it becomes liquid, and maintained in this condition throughout the laying operations. The floor blocks are dipped into the mastic, so that the lower part up to the bottom of the key or tongue and groove is covered. They are then pressed firmly down into position on the concrete.

A number of patterns may be obtained to suit individual tastes. The pattern is enclosed in a border of from two to four rows of straight blocks broken at the end joint.

HARDWOOD OVERLAY STRIP FLOORING

This type of flooring is not extensively known, otherwise it would certainly be more widely used. The cost, fully laid, cleaned off, and polished, works out at very little more than for a high-grade linoleum, and in durability and appearance it may be claimed to be substantially

Fig. 14.—LAYING BLOCK FLOORING

Dipping block to cover bottom with mastic solution in order to make it adhere to concrete floor.

superior. In fact, to the ordinary casual observer, overlay hardwood flooring is not distinguishable from a thick, solid, hardwood floor.

Sizes of Strips

Overlay strip flooring consists of thin boards, prepared all round, with square edges, to sizes such as $\frac{1}{4}$ in. by 3 in., $\frac{1}{4}$ in. by $3\frac{1}{2}$ in., $\frac{5}{16}$ in. by 3 in., $\frac{5}{16}$ in. by $3\frac{1}{2}$ in., etc., in random lengths, running from 4 ft. to 14 ft. Any species of hardwood may be used, but preferably oak.

How Flooring Is Laid

These strips are laid over a deal sub-floor with warm glue, and nailed through the top with panel pins—the nails being well punched. The resulting nail holes are " filled " before the surface is cleaned off and polished.

The strips may be laid either across or following the grain of the deal sub-floor, or, if the appearance is not objected to, diagonally. This latter makes for greater reliability if there is any doubt concerning the dryness of the sub-floor.

The important factor with overlay flooring and, indeed, also for parquetry flooring of any kind, is a really dry sub-floor, since any shrinkage underneath will obviously be reflected on the finished surface.

PARQUETRY FLOORING

Parquetry flooring is so well known as to need no description or recommendation. Its appearance is highly attractive, and, if well cared

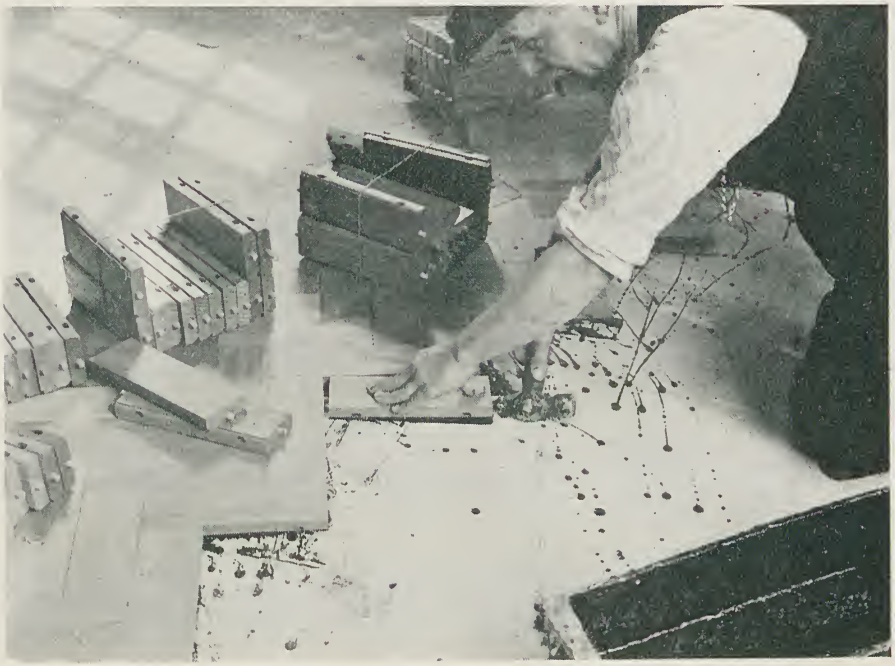


Fig. 15.—BLOCK FLOORING FIXED WITH BITUMEN SOLUTION TO CONCRETE FLOOR AND HELD IN POSITION BY DOWELS

for and the polish maintained, it will last almost indefinitely. Parquetry flooring may be laid direct on to a sub-floor or on a base of plywood, and is made up into an incredible variety of decorative designs by the fitting together and gluing of pieces of hardwood of geometrical shape.

Methods of Laying.—On a Sub-floor

In dealing with parquetry laid on a deal or other sub-floor, a "surround" is constructed and within the area thus enclosed the chosen pattern is formed.

The actual materials required for laying are the same as for the overlay flooring, viz. warm glue and panel pins.

On Plywood Base

In the alternative, the parquetry is first laid in the required design on a good pine plywood of stout thickness, in sheets of from 18 in. by 18 in. and upward. It is then placed in a press for a few hours, and afterwards scraped, cleaned off, and the plywood grooved on all four sides. The plywood is then glued and secretly nailed through the lower lip of the groove to the sub-floor, and each section glued and jointed together with cross-tongues.

Fig. 16.—SETTING OUT HERRINGBONE-PATTERN PARQUET FLOORING

Note the string line used as a guide. The flooring is pinned temporarily in place, as shown.

It must be noted that no parquetry will prove satisfactory when laid on an old existing floor unless the sub-floor has first been levelled and thoroughly dressed.

CLEANING OFF AND POLISHING FLOORINGS

Scraping.—By Hand and Machine

In cleaning off floorings there is nothing to equal the old-fashioned scraper—the method may be slow, and the work extremely hard, but it is well repaid by the resulting fine, smooth, satin-like surface. Alternatively, it is possible to hire machines which operate somewhat after the manner of a lawn mower, and are driven by electrical power. As, however, they are used diagonally across the grain, they leave behind them a mass of minute corrugations which no amount of polish will ever hide. Apart from the fact that these machines can only be employed in buildings where electrical equipment is installed, they are also unsatisfactory for use in rooms above the ground floor, inasmuch as the considerable vibration is liable to damage the ceilings.

Polishing

In regard to the final treatment of a floor, there are many proprietary brands of excellent floor polishes, but the best medium still remains pure beeswax and plenty of "elbow grease."

So far as maintenance is concerned, the need cannot be too thoroughly emphasised of frequent and regular polishing, for upon this is largely dependent the life of a floor. It is essential that the polish forms a permanent covering and protection of the wood from the tread, otherwise there will very soon be symptoms of wear.

Fig. 17.—LAYING PARQUET FLOORING
This shows gluing before pinning permanently. This is done in small sections as shown.

REPAIRING FLOORS

The repairs to floorings are of a limited nature, for any deterioration usually applies to the whole, and not to any one part, and, in consequence, it becomes a question of total replacement.

Areas Subject to Much Wear

At the same time, areas subjected to the greatest wear, such as around a doorway, or near the hearth, are liable to damage, and in these instances it is a simple matter to remove a few boards or blocks, as the case may be, and renew with others.

There are, however, several defects which may develop in a com-

Fig. 18.—PARQUET FLOORING AND SURROUND IN DOOR OPENING

Fig. 19.—LAYING PARQUET FLOORING
Punching panel pins before stopping and planing.

Fig. 20.—PLANING PARQUET FLOORING AFTER PINNING AND STOPPING

paratively recently laid floor, and most of which will probably be due to some external influence and not to the boards themselves.

Ridges Appearing along the Joints

This is a serious trouble, caused by the concrete or ceiling plaster under the floor not being fully dry. In effect, a damp moisture-laden atmosphere is always playing on the under sides of the floorboards, whereas their upper face sides are subjected to a normal and dry heat of, say, about 60° F., so that the one side swells and the other contracts, thus causing the top lip on the groove to " curl " upward. If immediate steps to remedy the defect are essential, there is no alternative but to get to work once more with plane and scraper. On the other hand, if left for a few months the condition will tend automatically to improve as the concrete or plaster becomes drier. This will induce a corresponding shrinkage on the under sides of the boards, thereby counteracting the tendency to " curl " on the upper side.

Shrinkage at the Joints

Once a floor has shrunk and " opened " at the joints it will never provide anything other than a poor and unsightly surface. By way of amelioration, however, if the shrinkage is not too great, it may be filled with one of the special floor-filling compositions available on the market. If the trouble is more serious, there is no alternative but to obtain slips of the same timber as the floor, prepared to the appropriate thickness, and these are glued and fitted well down into the crevices.

Wormholes

Wormholes will sometimes appear in a hardwood floor, and particularly in an oak floor. The trouble may be due either to contamination by a piece of old furniture, in which case the trouble may occur at any time, or to the egg of the lyctus beetle having been lodged in some crack of the flooring itself, when it will hatch and commence boring operations within a few months. Most species of boring beetle attack primarily the sapwood, but they will ultimately penetrate the heart-wood, and have a distinct preference for a new succulent timber as opposed to old. Immediately these wormholes become obvious—and they may be detected by a fine dust which will appear at the rim of the holes caused by their boring activities—the part of the floor infected should be removed and replaced. The remainder of the floor, although apparently sound, is nevertheless in imminent danger of attack, and should be thoroughly sprayed with Sumner's " D " solution.

NATURAL STONES USED IN BUILDING

PART I.—CHOICE OF STONE—MARKETING—SURFACE FINISHINGS—LIFTING—SETTING STONEWORK

WHEN choosing stone for a particular purpose a number of points have to be considered, such as the aspect and locality of the building, its architectural features, the position of the stone in the building, facility for working the stone, its appearance and colour, and its durability. It is also necessary to be certain that sufficient blocks of suitable size are readily obtainable from the chosen quarry. To ensure the best results it is essential that all stone intended for the important parts of a building should come from one district. After a stone has left the quarry it is difficult to know from which district it was obtained, but it is usual for each quarry to have its own identification mark, and to paint this on the surface of the stone.

CHOICE OF STONE

Architectural Detail

Architectural detail may limit the choice of stone ; in particular, carving and mouldings may prevent the use of granite or coarse-grained sandstone. It may also be necessary to note and take into consideration the class of stone used in other buildings in the same district ; in some towns the local authorities stipulate that certain stone must be used for new buildings in certain areas.

Appearance and Colour

The colour should be uniform, and the stone free from flaws, clay-holes, and other defects. In this connection the suitability of a stone should be judged not so much from its appearance when new as from its probable appearance when it has weathered for some time ; in manufacturing districts the face of a building is in a few years covered with a coating of soot and grime, and the stone face is hidden.

Locality and Aspect

The chief factor in the choice of a building stone is the climate to which it has to be exposed. Stone that has proved to be durable in

Fig. 1.—THE ROYAL LONDON MUTUAL INSURANCE SOCIETY'S PREMISES, LONDON

The three lower storeys are faced with granite to match more or less the old adjoining premises. The main building is in Portland stone. In the design, all superfluous features such as cornices, etc., have been eliminated, and variety of light and shade has been obtained by a deeply recessed central arch and by the disposition of the upper parts of the building in different planes. (*Architect : J. J. Joass, F.R.I.B.A.*)

the country air may quickly decay in the impure city atmosphere, or where exposed to the strong salt winds from the sea. Extremes of temperature are, generally speaking, prejudicial to the life of a stone. If a stone has been used previously in the same district, an inspection of the building in which it is used will give a clue to its behaviour in that atmosphere ; hard and durable stone will still show the marks of the tooling, and the arrises will be sharp and good after years of exposure.

The position of a stone in a building may very much affect its durability ; elevations exposed to frequent changes of temperature and the prevailing wet winds, chiefly south-west, are very liable to decay. In towns, fog is even more injurious than rain ; the countless particles of condensed moisture in a fog carry the dissolved gases of the atmosphere to the face of the stone, where they lodge and are driven into the pores by subsequent rain. Heavy rain is not always injurious since, under some conditions, it washes and cleans the surface of the building.

Facility for Working

The readiness with which stone can be converted into the various shapes required for different kinds of work is important from an economical point of view. There are several varieties of stone that would pass tests quite well as suitable for building purposes but, owing to their density and hardness, would not justify the installation of machinery for their production at the rate required.

It is really best for the stone to be worked in its own quarry district, as the masons on the spot are well conversant with the nature of the stone and, in the case of the more important stones, the necessary machinery is installed for economical working. Stone used in London and some other large towns, however, has to be worked away. Certain working agreements between the stone firms and the trade unions state that all stone shall be dressed by local labour in the particular town in which it is to be used.

Durability

The first essential in a building stone is durability. Granite is the most durable building stone, but it is too expensive for general building purposes. The durability of a stone will depend upon its chemical composition, its physical structure, the position in which it is placed, and, to a great extent, upon the relation between its chemical constituents and those of the surrounding atmosphere ; the same stone will weather differently according to the nature and extent of the atmospheric influences to which it is subjected. The various acids in the smoky air of towns, and the carbonic acid which exists even in the pure air of the country, ultimately decompose any stone containing a considerable part of carbonate of lime or magnesia ; oxygen, even in ordinary air, will act upon a stone containing much iron. The physical structure of a

stone is of importance, as on this greatly depends its power of resisting the action of the atmosphere. Stones which are crystalline weather better than those that are non-crystalline. Stone in external work should be non-porous.

A high wind is itself a source of destruction : it blows sharp particles against the face of the stone and thus grinds it away ; it also forces the rain into the pores of the stone and may thus cause a considerable depth to be subject to the effects of acids and frost.

Hardness of Stone

The hardness of a stone has to be considered if it is to be subjected to heavy wear, or is to be used for quoins, dressings, and other positions where it is required to preserve a sharp angle or arris. It does not necessarily follow that because a stone is hard it is more durable than a softer stone, as this quality is affected by the chemical composition of the stone irrespective of its hardness. Stones used for marine work should be hard, to resist the action of the water and possible injury from sand and stones washed against them.

Stone for Various Purposes

Granite, the hardest, strongest, and most durable of the building stones, is suitable for heavy engineering and similar work where strength and durability are necessary ; it is not suitable for carving, but makes excellent columns, plinths, pilasters, etc. When polished it gives a beautiful and lasting surface. Granite is difficult and costly to work.

Some varieties of limestone are suitable for external work, whilst others, such as Bath and Caen, are suitable for carving and internal work. The better varieties of oolitic limestones are suitable for all general building. The softer varieties of magnesian limestones are useful for internal dressings, and the harder for external work where dressings or moulded work is required.

The softer varieties of sandstone are suitable for internal plain, moulded, or carved work. The heavier and harder sandstones weather well, and are suitable for external work and heavy wear.

Marble is suitable for interior work such as wall linings, columns, etc., and in dry, sunny climates can be used for external work. Marble when polished is of special value for internal decorative building work.

Natural Bed

The natural bed of a stone is that on which it was originally laid ; this is not necessarily the same as it lies in the quarry, since the " lie " may have been altered by disturbances since the formation of the stone. The position of the natural bed of a stone in a building has an important bearing upon its durability. All stones having a laminated structure should be placed on their natural bed, as in this position they offer the

Fig. 2.—THE NATIONAL BANK BUILDING, LIVERPOOL

Steel-framed building, elevations faced with Portland stone, Cornish granite base. (*Architect : Bertram Ashworth, F.R.I.B.A.*)

greatest resistance to crushing. If placed with the layers parallel to the face of the wall, atmospheric action, especially that of frost and rain, will cause the layers to flake or scale off, and destroy the stone.

In arches, the bedding planes should be placed at right angles to the thrust of the arch, that is, parallel to the centre lines of the arch stones and perpendicular to the wall face.

Cornices and projecting courses, especially those with undercut mouldings which would be liable to flake off were the natural bed level, should have the natural bed vertical and at right angles to the face of the wall, except at the corners and return portions, where the stones should be horizontally bedded.

The natural bed can be determined in some stones by the position of imbedded shells, which were originally deposited horizontally; in others it can be traced by streaks of vegetable matter or by traces of the layers. Where, as happens with some varieties of stone, the natural bed cannot be seen, the mason can generally tell, by the working of the stone, which is the natural bed. It is often marked at the quarry.

The aim in the arrangement of the position of the natural bed is, in all cases, to obtain the maximum resistance to the pressure and to avoid having easily separated strata in the undercut portions of the architectural detail. For this reason the position of the natural bed is not so important in granular freestones, as these can be quarried in large blocks with no tendency to split in any particular direction.

Igneous rocks, formed by the action of heat, are definitely crystalline in character; they have no natural bed and can be laid in any position.

Seasoning

Most stones are the better for being seasoned, by exposure to the air, before they are set; this dries out the moisture or quarry sap; the drying should be gradual. It is best to work stone directly it is quarried, because freshly quarried stone is generally softer and more easily cut, and also because exposure to the air hardens the surface. The quarry sap in drying out forms a hard crystalline skin on the face, which makes the stone more durable. Because of this, worked stones should not afterwards have their dressed faces disturbed but should, when bedded, be covered with a wash of plaster of Paris and lime; this wash can be easily removed, and with it all dirt and stains, on completion of the building.

Weight of Stone

Where possible, heavy stones should be chosen for buttresses, retaining walls, and other massive work, the lighter stones being used for vaulting, domes, arches, and similar work. Weight is an indication of the density of a stone and therefore of its porosity.

Strength

Stone is weak in tension, and a large factor of safety must be used when it has to resist a tensional stress. Stones in building work, however, are generally under compression, and the compression in any ordinary building is never sufficient to cause any danger of crushing ; the weakest limestone will bear a compression of 60 tons per square foot, while the resistance of ordinary building stone ranges from 100 to 500 tons per square foot ; in the case of granites it rises as high as from 700 to 1,200 tons per square foot. In some particular cases, such as in some forms of arches and in retaining walls, considerable pressure may be concentrated upon certain points, which are thus liable to be crushed, in which case special provision has to be made for resisting the thrust.

Selection

A good stone should ring clearly when struck with steel, and break with a bright, clean fracture ; it should, when broken, show an even texture and be free from loose grains. The colour should be uniform, and the stone free from flaws and defects. Stones containing much iron should not be used for face work, otherwise the oxidation of the iron will cause unsightly rust stains on the face of the building. In order to obtain the best stone from a quarry it is often important that it should be taken from a particular stratum or bed ; in the same quarry some beds may be good and others almost worthless for building purposes. Portland stone is an example of this.

MARKETING OF STONE

The marketing of stone is a highly specialised business ; even those who are constantly using stone often do not realise the many varied stages through which the rough block passes before it reaches its final shape and is set in its allotted position in the building.

Stonework is not, and from its nature and use cannot be, standardised. Every single stone has to be dealt with separately, as a distinct unit, during its preparation. Machines are largely used at every stage of the preparation of building-stone blocks, but the stones are not mass produced, if we give this term its ordinary, everyday meaning.

To connect the units with the completed building, as designed by the architect, requires a skilled, efficient organisation. The actual stone-producing firms are the only people who have a really complete organisation for dealing with the supply of building stone from the quarry to the finished work ; the general builder not only obtains the stone from these firms, but his prices and estimates are, more or less directly, supplied by them. In many cases the stonework of a building is let off as a sub-contract, or a lump sum is included in the tender for this part of the work.

All the different building stones are supplied in random or dimension

block, sawn to size, or dressed ready for fixing. The standard or basis used in the selling of building stone is the foot cube. The stone is measured the net size of a cube which will contain the proposed finished block. When the dimensions of the stone include a fraction of an inch the next inch is taken. Waste in conversion is allowed for in all systems of measurement; one method is to add an inch each way beyond the net dimensions of the finished block. The general practice is to take the cubical contents of the stone, and then the "labours" executed upon it; there are, however, exceptions to this in some cases. It is usual with York stone in the London area to combine material and labour in one item.

Random and Dimension Block

Stones sold under these terms are unprepared blocks as taken from the quarry stack; that is, they are roughly squared with the quarry axe, but are not prepared in any other way. The size of the stone varies according to the size of the quarried block, and it is generally the largest rectangular solid obtainable from that block. The blocks are measured and marked or numbered when stacked and the particulars are booked and also painted on the stone. The measurements—that is, the cubical size—form a basis from which to calculate the price and weight. Until recently the railway companies accepted the marked measurements for rail charges, but they now charge by weight as for other goods. In many quarries the quarrymen's pay is based on the output, in foot cube, of block stone.

Every variety of building stone has a current market price, per foot cube, and for practical purposes a fixed number of cubic feet to the ton. Thus, Portland Whitbed is at the present time quoted at 4*s.* 7*d.* per foot cube and as being 16 cu. ft. to the ton. An addition to the price per foot cube is made for blocks over 20 cu. ft., and a further addition for those over 30 cu. ft.

Sawn to Size

Stone sold under the term sawn to size is cut by frame or other saws. The surfaces of the stone are not prepared or dressed, but are left as they come from the saw. An addition to the current market price of block stone is made for sawing, or half-sawing, in pricing stones sawn to size. Ashlar consists of stones sawn to size, but the faces have to be dressed, and this class of work is included with dressed stone.

Dressed Ready for Fixing

The stone for practically all stone buildings is included in this term, and a brief outline of the stages of production before the stone is actually in position in the building is useful. The work, as far as the supply of stone is concerned, starts with the receipt, by the stone firm, of the

architect's plans and elevations, together with the plans and details of the steelwork. The architect's drawings are drafted to scale on working masonry drawings, and these show every stone, numbered and dimensioned, and the position of all beds and joints. The steelwork is also shown on the drawings, so that the necessary notchings in the stone can be set out. It may be noted that one of the biggest problems of the masonry contractor is to know how to deal effectively and economically with the large amount of notching and cutting necessary to accommodate the steel framework in a modern building. The steelwork has also to be studied in other ways: often the position of the joints and beds is affected by the steel framework; the careful planning of the joints often makes the notching less difficult.

The drawings, or layouts, are sent to the architect for his approval or alteration, and dimensions are checked, as far as possible, with the builder on the site. When the drawings are passed as correct, the sizes of the stones are taken and suitable blocks obtained from the quarries. The dimensions of each stone, with a sketch showing all notchings, etc., is booked, and copies of the entries made for workshop use. Each contract has an order number, and every stone for the job, in addition to being booked to the order number, has its own number. The stone number corresponds with the number given to it on the layout where its actual position in the building is shown. Blue-prints are made of the layouts, for use in the office, by the works foreman, and as a fixing sketch.

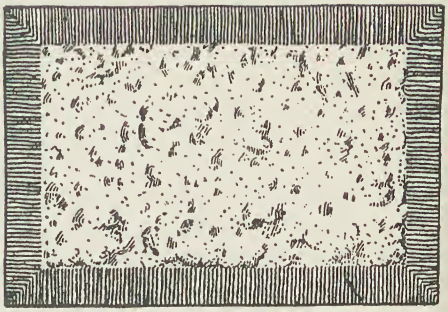
Full-size drawings are made from the layout to obtain the necessary sections, bed moulds, and developments, and these are cut out in zinc for use by the mason when cutting the stone.

The blocks of stone are cut to height by frame saws, and further shaped by diamond saws. Moulding, notching, sunk surfaces, etc., are worked, as far as possible, by various types of moulding machines and carborundum saws. Detail and those parts that cannot be machine worked are finished off on the banker. Finally, identification marks are cut in the top surfaces and, with smooth-faced stones, the faces are rubbed and gritted to the required finish. The stones are then checked with the moulds, and the layout is marked to show that the stone is finished or has been sent to the building.

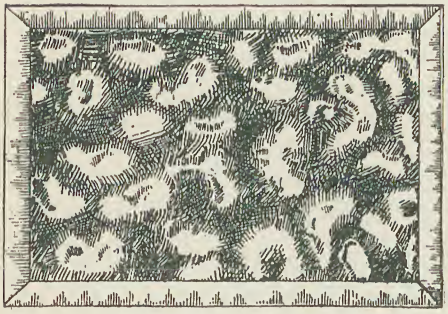
SURFACE FINISHINGS ON BUILDING STONES

The manner in which stone faces are finished varies with the nature of the stone and the effect it is desired to produce. The appearance of stonework will vary according to the tool used and the way in which it is used. With hard freestones the surface will remain for years as worked by the mason, and in these cases it is worth taking extra trouble to produce a surface that will improve the appearance of the masonry. With soft freestones the surface is less permanent, and tool marks will

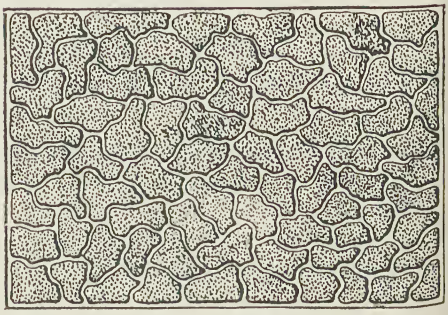
Rock faced.



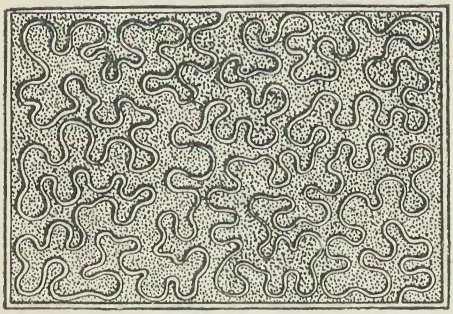
Punched, with drafted margin.



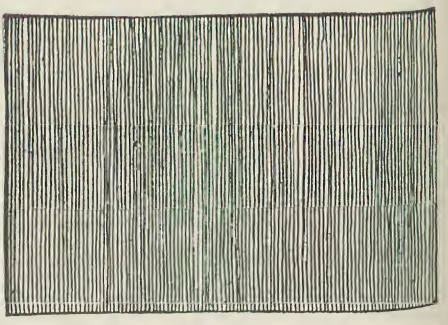
Rusticated and chamfered.



Reticulated.



Vermiculated.



Tooled.

Fig. 3.—STONE SURFACE FINISHINGS ON BUILDING STONES

disappear more quickly—for this reason these stones are usually worked to a smooth face.

Raised Surfaces

For large blocks of stone it is not always necessary to reduce the whole of the face to a level surface, except for a short width around the edges of the stone, which must be done to ensure true setting when fixing the stone. The centre portion of the face can be left with a more or less rough surface, as described below.

Rock Faced

This term is used for stones which have their surface dressed with a spalling hammer or pitching tool, and only the edges worked or tooled to the regular plan. The worked edges are termed drafted or tooled margins.

Punched Rock Face

This finish is similar to rock faced but with a less rough surface ; it is more suitable for smaller stones than the rock-faced surface. This surface is formed with the punch, which is driven in a nearly vertical direction, forming small pits between which the stone splits off in flakes.

Broached

This surface is in the form of a series of ridges across the face of the stone ; it is worked with either a punch or a point, according to the hardness of the stone and the fineness of the required finish.

Rusticated

The surface for this finish is worked into a series of ridges and hollows, the treatment gives a bolder effect than the broached surface. The term rusticated is also used for projecting courses in stonework, and for work with rebated joints.

Reticulated

Reticulated work is composed of a series of sinkings, worked in a smooth surface ; the margins between the sinkings are of fairly uniform width, and the sinkings fairly regular.

Vermiculated

This has a surface similar to the reticulated, but with irregular sinkings arranged somewhat in the character of the convolutions of a worm.

Flat Surfaces

Stones that are finished with a flat surface can be treated in various ways. The finish here depends upon the tool used, and the different disposition of the tool marks.

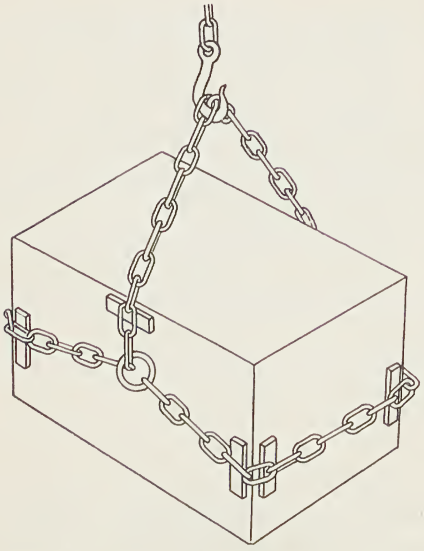


Fig. 4.—SLING-CHAIN METHOD OF LIFTING STONE BLOCKS

There is a danger with this method of chipping the arrises.

Random Tooled

In this form of finish the tool marks are disposed irregularly over the surface.

Tooled

When the surface is tooled in regular broad lines, forming bands right across the stone, it is known as tooled work. Where the tool marks are in diagonal lines it is termed stroked or droved work.

In all tooled surfaces the tooling may be continued to the edge of the stone, or a margin may be worked round the edge to give a panel effect in the centre.

Rubbed Face

Where the stone is subject to direct wearing action the surface is usually rubbed smooth, after it has been dressed to a fairly fine face. Soft stones are finished with the drag, which produces a level, smooth surface free from tool marks. The drag used is a broad piece of toothed-edge sheet steel, with coarse or fine teeth to suit the particular stone or the degree of fineness required for the finished surface.

Polished Surfaces

Granite when used for decorative or monumental purposes is generally polished. The surface to be polished is first dressed to a level face, and then rubbed smooth under an iron rubber with the aid of sand and water, emery, and other abrading substances ; finally it is polished with thick felt and putty powder. Marble is polished by much the same process. Nearly all polished stonework is polished by machinery, and only small stones or intricate details are worked by hand.

Hard stones of a crystalline structure are the only ones suitable for polishing. The difficulty of working these, and the large amount of labour necessary to produce the finished surface, make this type of finish costly ; in consequence, polished stonework is used only for special work in building.

LIFTING STONE BLOCKS

The usual method of lifting any heavy load is by means of a sling chain (Fig. 4). Blocks of stone lifted by this method, however, are liable

to have the arrises chipped by the pressure of the chain ; pieces of wood placed between the chain and the stone will help to avoid this, but it is better with worked stone to use one of the following methods.

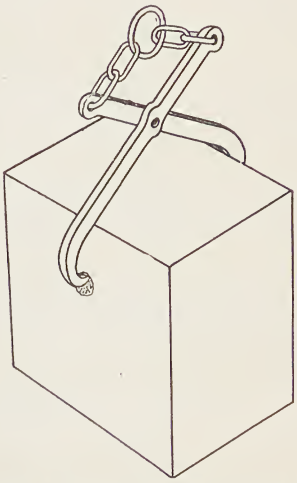


Fig. 5.—USING LIFTING TONGS
With this method, the heavier the load the tighter the grip.

Lifting Tongs

Soft stones can be lifted by means of lifting tongs. These tongs are made of two pieces of iron pinned or pivoted together like a pair of pincers. The lower end of each piece is hook-shaped, and the upper end has a hole to take a chain connection between them. The hooked ends grip the stone, and the construction of the tongs is such that, when in use, the heavier the load the tighter the grip.

Lewis

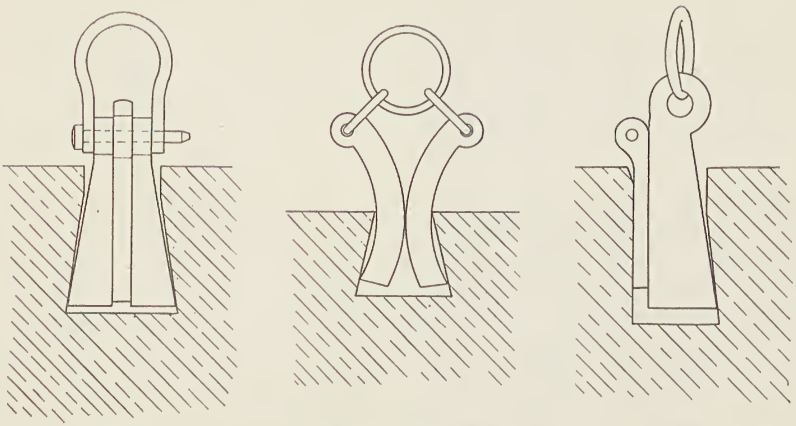
Dressed stones are usually lifted by means of a lewis (Fig. 6). The common lewis consists of three pieces of iron and an iron ring or eye to receive the crane hook. The two outside pieces are of a dovetail shape, and the centre piece is parallel throughout. The method of using a lewis is to insert the outer portions into a dovetailed mortice cut in the top of the stone, and to force the centre piece down between them, this causes the outer pieces to grip the sides of the mortice ; finally the eye is placed over the three pieces, and the whole connected and held together by a cotter or split pin. When the stone is in position the lewis is removed by using the same methods in reverse order. This method of gripping and lifting stone avoids all damage to the face and ends.

Plug and Chain Lewis

Another form of lewis (Fig. 6) consists of two parts connected together with three rings at the top. One piece is curved and the same thickness throughout, and the other is of a curved dovetail shape. For this form of lewis the mortice is undercut, so that when the plug is at the bottom of the hole the curved key can be inserted ; the action of lifting makes the whole tight and secure.

Lewis for Use under Water

This has the plug dovetailed only on one side, and a straight key. It is suitable for work under water since, if a chain is fastened to the key and the free end of the chain brought to the surface of the water, the key can be easily withdrawn after the stone is set.



Lewis. Plug and chain lewis. Underwater lewis.

Fig. 6.—VARIOUS TYPES OF LEWIS USED FOR LIFTING STONE BLOCKS

Lifting Pins

The common form of lifting pin is simply an iron pin on a chain; in use, two of these pins are driven into the stone and the chains are connected to the crane hook. A much better form is composed of two curved pieces of iron each with a hole at one end; a chain passes through the holes and the ends of the two chains are connected together by a ring for attachment to the crane hook. The pins are placed in an inclined mortice cut in the stone, and the tension of the lifting chain causes the lower ends of the pins to open and grip the edges of the hole in the stone.

Lifting Dogs

These consist of a pair of iron hooks strung on a chain loop. The hooks grip the stone, and the chain is connected to the crane. Lifting draws the tops of the hooks together and tends to give them a firmer grip on the stone. Lifting dogs are useful but have many disadvantages.

SETTING STONEWORK

In setting stonework careful consideration must be given to the choice of, and the reason for using, a setting material. Greek masons, in the best period of Greek masonry, built their walls dry; mortar was neither used nor necessary owing to the perfect accuracy of their worked joints and smoothed beds. Modern work does not reach this high standard, and some form of mortar is always required.

The mortar used must be of such a nature that it does not stain the stone or show as a discoloration at the beds and joints; it must provide the necessary adhesion, and the quantity used must be the minimum that will ensure a proper bedding of the stone. All setting materials

used must be carefully mixed and have the ingredients in the correct proportions.

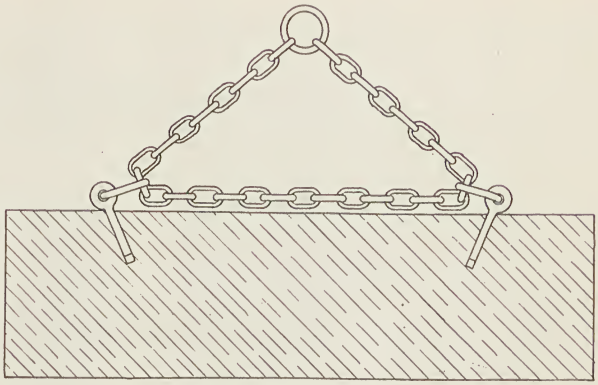


Fig. 7.—LIFTING PINS

Mortars for Rubble Walling

For rubble walling and similar work, where the strength depends to a great extent on the setting properties of the mortar, a binding material of good setting quality is essential. Suitable mortars would be 4 parts of sand to 1 part of Portland cement, or 3 parts of sand to 1 part of hydraulic lime.

Setting for Dressed Stonework

Dressed stonework, which depends for its strength on the arrangement of the bonding and the large, true, bearing surfaces, does not require a hard-setting cement. For work of this description, mason's putty, consisting of 3 parts stone dust and 1 part lime putty, is generally used for bedding, the joints being grouted with neat Portland cement or with a mixture of 3 parts stone dust to 1 of cement. Keene's cement is often used for grouting instead of Portland cement for stone such as Portland, but it is better to use a white Portland cement for this class of work. Where the courses of stone are supported by steelwork and depend on the cementing material for stability, it is advisable to fill all spaces between the stone and the steelwork with neat Portland cement.

Setting for Polished Granite

A suitable setting material for this is composed of 2 parts of washed sand to 1 part Portland cement, or 2 parts granite stone dust to 1 part cement.

Marble Settings

For setting white marble, "Atlas" white cement is an excellent bedding material. For marble wall linings, plaster of Paris and Keene's cement are the most suitable mortars.

Mixing Mortars

When mixing mortar it is important that the materials are first thoroughly mixed when dry, and that all water used in mixing is clean

Fig. 8.—NEVILLE HOUSE, WATERLOO ST., BIRMINGHAM

Entrance hall, finished with Triani marble. (*Architect: W. Norman Twist, F.R.I.B.A.*)

and free from dirt and vegetable matter. The sand used must be clean and sharp. Mortar should be used immediately after the water is added, and only enough to last for a few hours should be mixed at a time. Cement or hydraulic lime mortar should never be mixed a second time.

In wrought-stone walls the mortar need not be hard ; its chief object is to keep wet out of the beds and joints, and to form a seating for the stone. It is best to bed the stones so that the beds are left open for about $\frac{3}{4}$ in. from the face, to prevent spalling owing to imperfect bedding, and to point these joints when cleaning down at completion.

NATURAL STONES USED IN BUILDING

PART II.—FIXING AND SECURING BUILDING STONES —TESTING—PRESERVING—TYPES OF STONE

WHERE the adhesion due to the setting material is not sufficient to ensure the stability of the masonry, additional means have to be used to secure the stones. This additional security is obtained by working special joints on the stone, by the aid of cramps or fastenings, by bolting the stones to each other or to the building structure, or by attaching the stone to steel sections provided in the framework for the purpose.

Cramps for Securing Building Stones

Metal cramps (Fig. 1) are used for securing stones in cornices, gable copings, small-depth face stones, and projecting string courses. They are generally about 10 in. long, and bent at right angles about $1\frac{1}{2}$ in. at each end. The cramps may be made of iron, copper, bronze, or stainless steel. Iron cramps have great tensile strength, but must be galvanised or treated with some preservative, to prevent oxidation ; copper is non-corrosive, but its tensile strength is much less than iron ; bronze is harder, but in other respects it is similar to copper ; stainless steel is a comparatively new metal to be used for cramps, but is probably the best metal for the purpose.

Cramps are fixed by cutting a chase in the stones for the flat portion, and dovetailed mortices to receive the roughened ends. The cramps are bedded in Portland cement, lead, or asphalte ; the bedding material should completely cover the cramp.

Slate cramps (Fig. 2) are pieces of slate cut with dovetail ends, generally about 6 in. long, 2 in. thick, and $2\frac{1}{2}$ in. wide at the ends. They are sunk into the stone, with the dovetailed ends in adjacent stones, and set in Portland cement.

Joggle Joint

This joint is made by working a projection on one stone and cutting a corresponding recess in the adjoining stone to receive it ; the recess must give sufficient clearance for the setting material and for easy

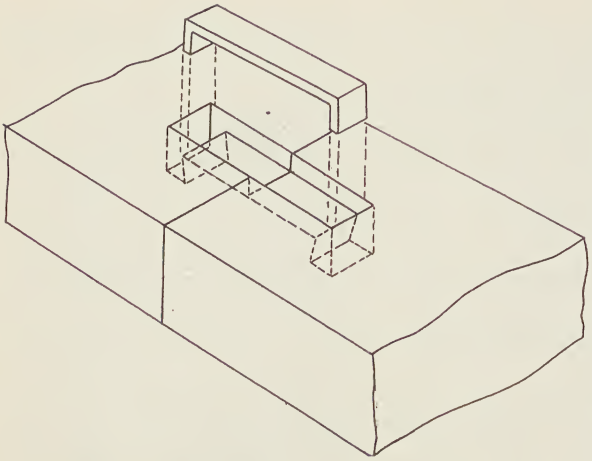


Fig. 1.—METAL CRAMP FOR SECURING STONES

The cramp is bedded in Portland cement, lead, or asphalte, which should completely cover it.

fitting. A chase is cut in the side joint, from the joggle to the surface of the stone, and cement grout is poured through this into the joint when the stones are in position. It is not usual to show the joggle on the face of the work; this is avoided by stopping it a short distance back from the face.

Table Joint

This joint has a rectangular projection worked on one stone which fits into a mortice cut in the other. In one form of table joint the projecting tongue is in the form of a dovetail, so that the stones are dovetailed together, but this type is used only for special work where great strength is necessary.

Special Use of Joggle Joints

When used on landings, joggle joints help to distribute the load and also to maintain a level surface. They are sometimes used for the joints of large voussoirs in arches, but their use in this connection is not always an advantage. Table joints and joggle joints offer great resistance to lateral pressure, but they are costly both in material and in labour.

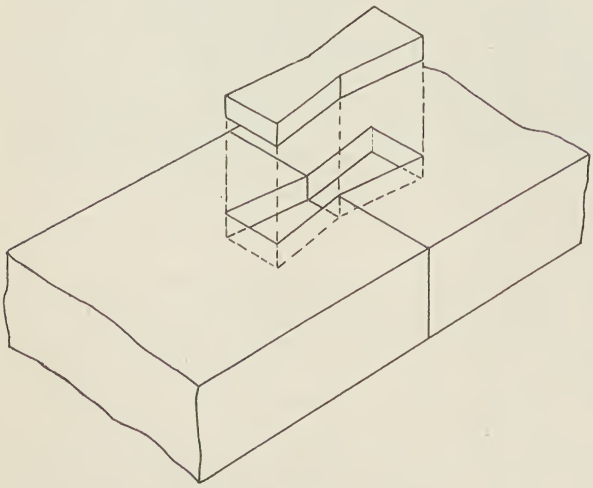


Fig. 2.—SLATE CRAMP

This is set in Portland cement.

Screwing to Stonework

A satisfactory method of fixing screws or coach bolts to stone is to cut a hole in the

stone and to plug this with a tight roll of sheet lead. The bolt is screwed into the centre of the lead plug and it makes a secure fixing (Fig. 5).

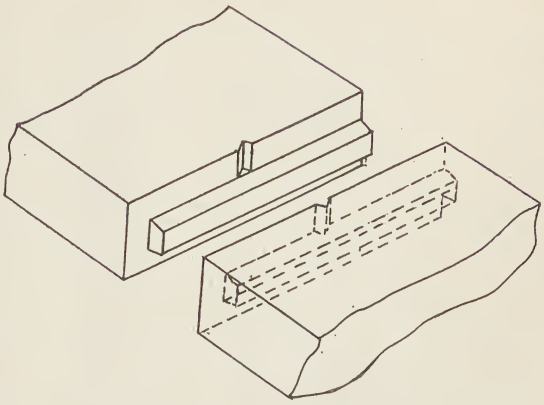


Fig. 3.—JOGGLE JOINT

Note the chase for pouring in cement grout when stones are in position.

Lead Plug

Stones may be connected together by means of a lead plug. For this, dovetailed mortices are cut in the joints of two adjacent stones, and a connecting slot from the mortices to the top surface. When the stones are in position the slot and mortices are filled with molten lead which, when cool, is caulked, to completely fill the holes and thus secure the stones.

Anchor Bolts

Heavy projecting courses are secured from overturning by means of anchor bolts or tailing-down bolts. These are bolts of sufficient length to reach from the top of the stone, to be secured at a point at some distance down the wall. They pass either through holes cut in the stone or through a chase cut in the back surface. The bolt, at the lower end, is passed through an iron plate, built into the wall, or the bolt is secured to the steel framework; a large washer is placed under the nut. When the projecting stone rests on a R.S.J., the anchor bolt is reversed (Fig. 7). When anchor bolts are used the stone must be well supported, by some form of strut, until set, and the bolt tightened up before the strut is removed.

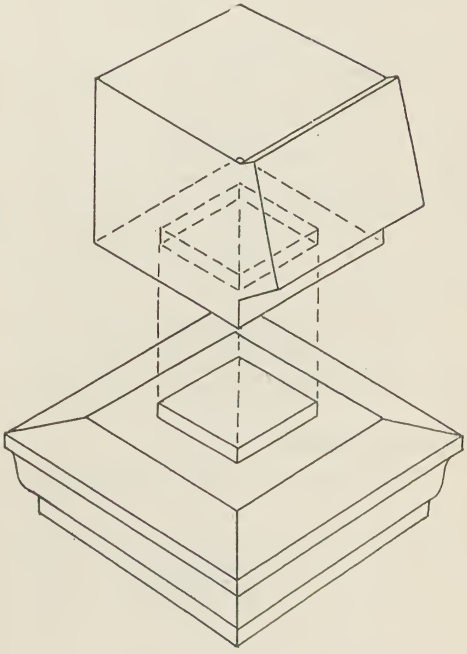


Fig. 4.—TABLE JOINT

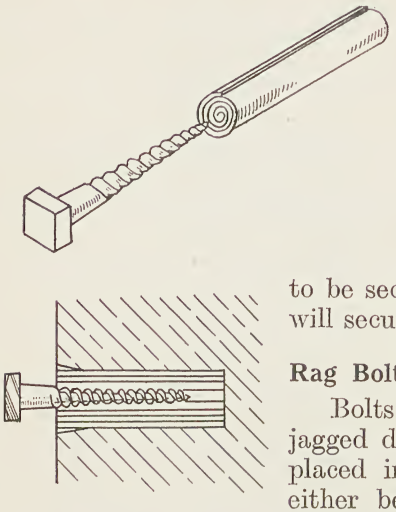


Fig. 5.—FOR SCREWING TO STONEWORK

Coach bolt fixed in stone. The hole is plugged with a tight roll of sheet lead.

Anchor bolts are also used for fixing facings to steelwork. When used in this way the head end is made in the form of a T, the projecting ends of which fit into holes cut in the stone to receive them, or in the form of an eye (Fig. 8). In the latter form a dowel is passed through the eye, and the ends of this fit into holes cut in the stones to be secured. One anchor bolt fixed at a joint will secure two adjacent stones.

Rag Bolts

Bolts fixed in stone are often made with a jagged dovetail-shaped end; this shaped end is placed in an undercut hole in the stone, and either bedded in cement or fixed by running with molten lead. The bolts, known as rag bolts or lewis bolts, are useful for many fixing purposes, but where the upward pressure is great it is safer to use anchor bolts and plates.

Dowels and Joggles

Stones in mullions, columns, and similar work are secured, to prevent lateral movement on the bed joints, by means of dowels or joggles. Dowels (Fig. 11) may be of either slate or metal, and circular, diamond-shaped, or rectangular in section; in some cases dowels are tapered at the ends. Slate joggles (Fig. 10) are rectangular pieces of slate about 6 in. long and 1½ in. square. One half of the thickness is recessed into each of the two stones to be secured, and the joggle is set in cement.

Extra security against movement of stone at the joints is obtained by means of dowels, cement joggles, and joggled joints. Dowels used in joints are similar to those described for beds.

Cement Joggles

These are made by cutting a V-shaped sinking in the joint of each stone, shaped like an inverted Y with each arm of the letter about 4 in. long. When the stones are in position the recesses are filled with liquid cement

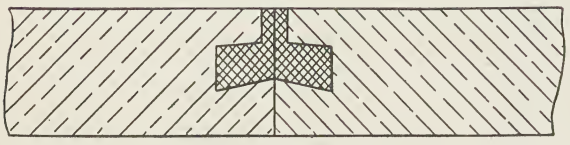


Fig. 6.—LEAD PLUG

which, when set, forms a solid joggle with half its thickness bedded in each stone. Cement joggles are chiefly used in the top courses of stonework, such as cornices, etc.

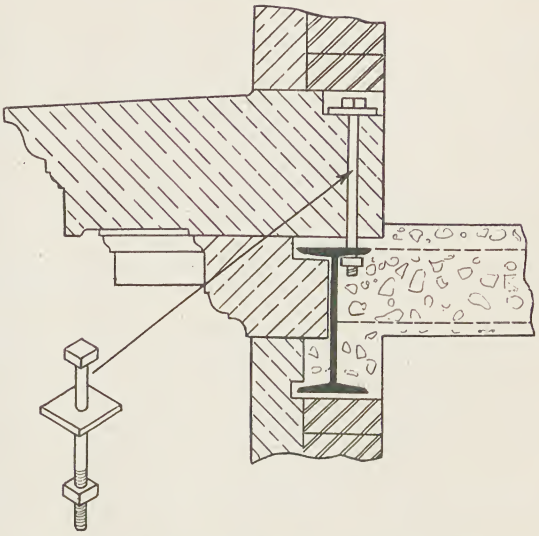


Fig. 7.—HEAVY PROJECTING COURSE SECURED FROM OVERTURNING BY ANCHOR BOLT

Connecting Stone to Steelwork

With modern stone buildings it is the general practice to erect a steel-framed structure and to use stone as a facing material. This method of building necessitates some special provision for connecting and securing the stones to the steel framework. When possible, the connection is made by cutting suitable "checks" in the stone, to receive the steel member of the framework to which it has to be fixed. Where this method is not suitable some form of metal connection may be used.

The form of the connection will depend upon the type of building in which it is used; it may be either a bolt, cramp, dowel, or some special form made for the particular work. Connections may be made of iron or steel, but if these metals are used precautions must be taken to prevent their oxidation, otherwise the expansion caused by the layers of rust may result in serious damage to the stonework. Iron or steel connections can be galvanised and embedded in cement to prevent this oxidation, but it is better to use non-corrosive metals, such as copper,

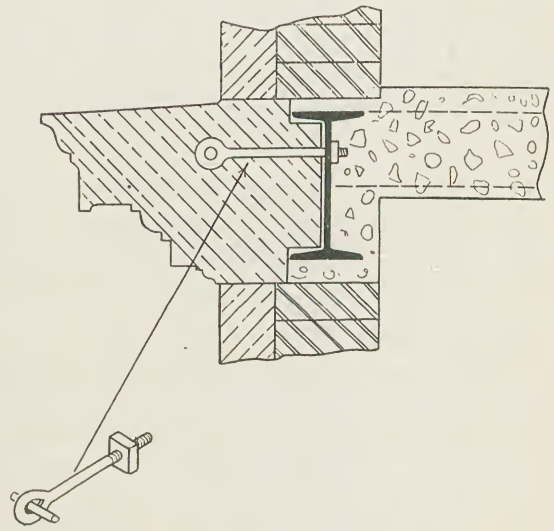


Fig. 8—USING ANCHOR BOLT FOR FIXING FACINGS TO STEELWORK

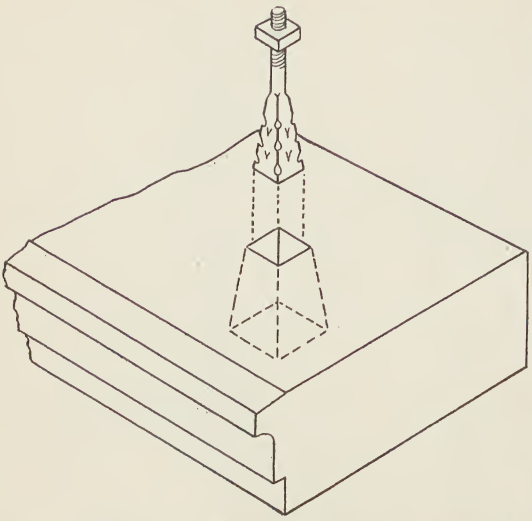


Fig. 9.—RAG BOLT BEDDED IN CEMENT OR FIXED BY RUNNING WITH MOLTEN LEAD

gun-metal, or stainless steel, for all connections actually in contact with the stone. It should be noted that even when the metal is built into the stonework it is still subject to atmospheric action owing to the more or less porous nature of all building stones.

When fixing metal connections to stone and steelwork, provision must be made for tightening up, during the erection of the building, after the stones are grouted and partially set.

FIXING LEAD TO STONE

Sheet lead is used as a protective covering for exposed portions of stonework, such as the upper surfaces of projecting cornices and string courses, and also for flashings, at the interpenetration of walls, roofs, and chimneys. The lead is secured by means of raglet and wedges, by burning in, or by lead dots.

Raglet

A raglet is a narrow groove, about $\frac{3}{4}$ in. deep, cut in the stone to receive the edge of a sheet of lead. The edge of the lead is fixed in the raglet by wedging with lead wedges and pointing in with cement.

Burning In

A better way of fixing lead is by burning in. This is done by pouring in molten lead to fill the raglet ; the hot metal heats, and unites with, the edge of the sheet lead, and firmly secures it. When the metal is cool it must be caulked to compensate for the contraction due to cooling.

Lead Dot (Fig. 13)

Sheet lead covering the top surfaces of cornices is secured at the inner edge by building the blocking course on it, during the erection of the building, or by turning the edge up the vertical face of the wall for about 2 in., and dressing it into a joint, where it is fixed by wedging and pointed in with cement. The front edge is secured by means of lead dots. Undercut holes are cut in the stonework near the front edge and at about 15-in. centres ; the stone is then covered with sheet lead, and holes are made through this to coincide with the holes in the stone.

Finally, the holes are filled with molten lead, which is poured through a small mould. The mould forms a spherical head overlapping the sheet, and this is termed a lead dot.

Templates

Beams, girders, etc., that rest on stone walls, may cause crushing of the joints immediately beneath them unless some provision is made for distributing the superimposed load over an area larger than the actual area of the bearing surface. The usual method of dealing with this difficulty is to let the end of the girder rest on a large stone, termed a template or padstone, the surface area of which is sufficient to ensure safe uniform spreading of the load. The actual area, and the thickness of the template, are governed by the particular applied load in each case, and the size of the stone should be such that it will work in with the normal bonding of the wall.

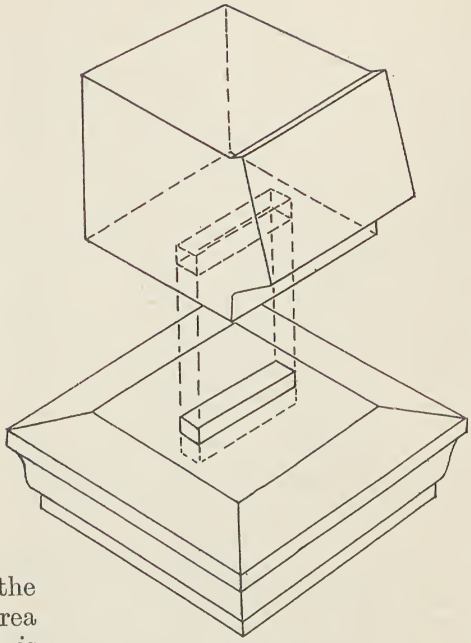


Fig. 10.—SLATE JOGGLE
The joggle is set in cement.

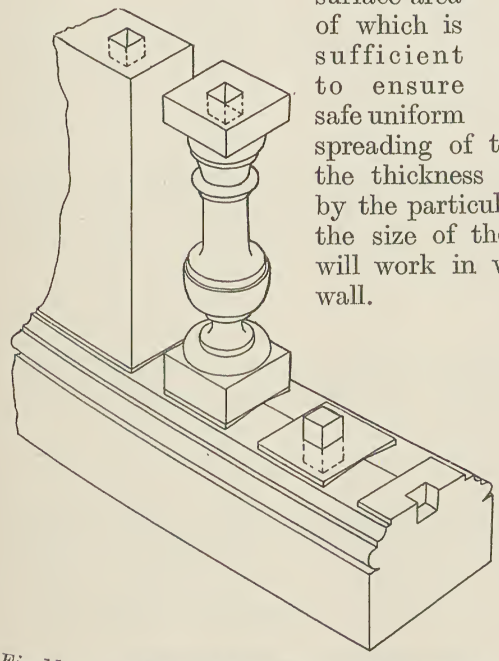


Fig. 11.—DOWELS ARE USED TO SECURE MULLIONS, COLUMNS, AND SIMILAR WORK, TO PREVENT LATERAL MOVEMENT ON THE BED JOINTS

Cover Stones

A wall that has to be built directly resting on rolled-steel girders, and especially if the wall is composed of small stones, should have the course immediately on top of the girder composed of stones taking the whole thickness of the wall. These stones, which are known as cover stones, are used to distribute the pressure more evenly. The most suitable

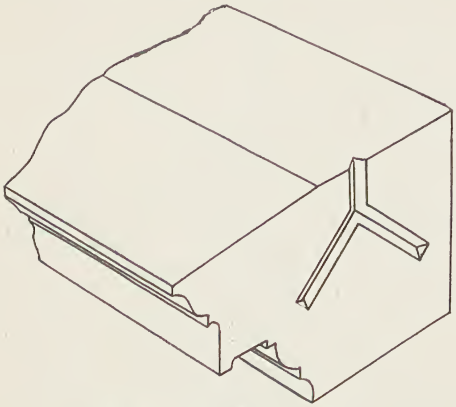


Fig. 12.—CEMENT JOGGLE

stones, both for cover stones and for templates, are the harder varieties of sandstone; granite offers a greater resistance to crushing, but no ordinary building stress will crush a sandstone block.

Protection during Building

Projections such as string courses, cornices, and cills must be protected from damage by covering with rough boards and, to avoid stains, the face of the stone should be covered with slurry. On completion of the work the slurry is cleaned off and the boards removed, leaving the face clean and edges undamaged.

TESTS FOR BUILDING STONE

Thorough tests of building stone can be carried out only in a properly equipped laboratory, and even then the results obtained can be used only as an indication of the quality and possible durability of a stone. The following simple tests can, however, be used by the practical man as some guide to the quality of a stone.

Absorption

Carefully weigh samples of the stone to be tested, and soak these for about 48 hours in water, wipe the stone, and again weigh. The difference between the weights will show the amount of the water absorbed, and thus indicate the porosity.

Fracture

A newly broken piece of stone should be bright, clean, and sharp, with grains well cemented together. An earthy appearance shows a stone liable to decay.

Acid Test

Soaking a stone for a few days in dilute solutions of sulphuric acid and hydrochloric acid will indicate how the stone may react to a town atmosphere. A few drops of the acid on a stone will show, by effervescence, if carbonate of lime or carbonate of magnesia is present.

Test for Earthy Matter

Place a few chippings, or pulverised stone, in a glass of clean water and leave this undisturbed for a few hours. At the end of the time

shake the glass, and if earthy matter is present the water will show a cloudy, turbid appearance.

It should be noted that the ultimate test of a building stone is its behaviour after it has weathered for years in the building. All other tests can be used only as a guide.

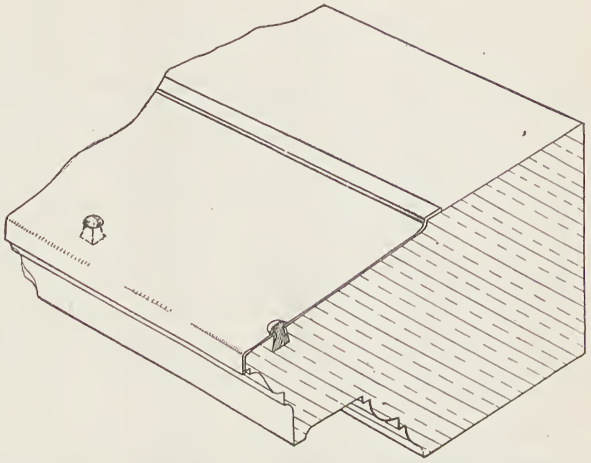


Fig. 13.—SECURING LEAD SHEET BY LEAD DOTS

PRESERVATION OF BUILDING STONES

How Decay Occurs

Stone buildings deteriorate through moisture percolating the pores of the material. The moisture may contain minute quantities of acids which affect the stone ; or in frosty weather the increase in volume which takes place when water freezes may cause particles of the stone to spall off.

Some stones more or less form their own protective coat. The quarry sap contained in these gradually works its way to the surface, where the moisture evaporates, leaving the surface pores filled with the sediment. Where this deposit is siliceous the surface is improved and made more acid resisting. Any subsequent cleaning of the surface by a method which actually removes this protective coat may be detrimental to the future life of the stone.

Most stone preservatives act in a similar manner ; they contain substances which are finally left as a deposit at the surface, and tend to fill the pores.

The decay in buildings is caused by physical and chemical processes which generally act together. The destructive action may be helped by faults in the stone, by badly designed buildings, or through defective construction, which by allowing moisture to gain access to the interior of the stone causes it to decay.

Serious damage is often caused by the rusting of iron cramps and dowels ; these increase in volume as they rust, and cause the stone to burst and spall.

Preservation of Stone

The design of the building may affect the durability of the stone used in its construction. Points such as properly made and suitably placed throats and drips ; good weatherings on cills, cornices, and

projecting courses; mouldings designed to avoid deeply undercut members, will all help to make any stone more lasting.

Generally the method employed to preserve stone is either to cover the surface with a protective coating, or to fill the surface pores with some material which hardens and resists decay.

Painting the surface with ordinary oil-colour preserves stone, but completely hides its natural beauty. Boiled linseed oil is sometimes used as a preservative, one or two coats being well brushed on after the work has been cleaned. Its use darkens the colour of the stone and may result in a patchy appearance.

Several processes for preservation consist of coating the stone with a solution of soluble silica. Generally these solutions are invisible when applied, but they harden the surface and make the stone more durable.

Limestones can be coated with a siliceous preservative, prepared by the Bath and Portland stone firms, known as "Fluate." With this, the stone is first cleaned and then the solution is laid on with a brush. "Fluate" hardens and preserves new work, and checks the decay in old work; it does not materially alter the colour or apparent texture of the stone.

Much decayed stonework may be restored by Tabard's Metallic Stone, which is a natural stone reduced to powder. This powder is mixed with an acid, and when applied to the decayed work it unites with the existing stone and restores it.

LIST OF GRANITES

The best granite stones are used for polished and decorative work, and the others for general building. Cutting to finished sizes, dressing, and polishing are done in the mason's yard. Granite will take a high polish; it weathers better than any other building stone, and is suitable for all classes of work except where fine detail is required. Granite is generally too costly for ordinary building purposes, and it is used chiefly for heavy engineering work and parts of structures subject to continuous hard wear; its surface is entirely destroyed by the effects of fire, and owing to its granular structure and hardness it is not suitable for carving.

Cheesewring Granite.—Colour, light grey; rather coarse grained; weight, 168 lb. per cu. ft. Quarried at Linkinhorne, Cornwall. Chiefly used for heavy engineering work.

Colcerrow Granite.—Colour, light grey; coarse grained, with large oblong crystals; weight, 168 lb. per cu. ft. Quarried at Par, Cornwall. Used for heavy engineering work.

Correnie Granite.—Colour, salmon, grey, and red; medium grained; weight, 162 lb. per cu. ft. Quarried near Alford, Aberdeen. Used for building and engineering work.

Dancing Cairns Granite.—Colour, usually light grey; medium

grained ; weight, 170 lb. per cu. ft. Quarried near Aberdeen. Used for building and engineering work.

De Lank Granite.—Colour, light greenish-grey ; fine, close grain ; weight, 165 lb. per cu. ft. Quarried at Bodmin, Cornwall. Used for general engineering work.

Dyce Granite.—Colour, dark grey ; fine grained ; weight, 165 lb. per cu. ft. Quarried at Dyce, near Aberdeen. Used for general building work.

Kemnay Granite.—Colour, light silvery grey ; medium grained ; weight, 160 lb. per cu. ft. Quarried near Aberdeen. Used for engineering and general building work.

Penryn Granite.—Colour, medium grey ; coarse grained ; weight, 165 lb. per cu. ft. Quarried at Penryn, Cornwall. Used for engineering and building work.

Peterhead Granite.—Colour, red ; coarse grained ; weight, 158 lb. per cu. ft. Quarried near Peterhead, Aberdeen. Used for building, engineering, and monumental work.

Ross of Mull Granite.—Colour, pink to red ; coarse grained ; weight, 175 lb. per cu. ft. Quarried at Ross of Mull, Argyllshire. Used for general building and engineering work

Rubislaw Granite.—Colour, dark grey ; fine grained ; weight, 163 lb. per cu. ft. Quarried at Aberdeen. Used for building and engineering work.

Shap Granite.—Colour, pink and reddish brown, dark and light ; coarse grained ; weight, 160 lb. per cu. ft. Quarried at Shap, Westmorland. Used for columns, general building and engineering work.

LIST OF LIMESTONES

The essential characteristic of all true limestones is the presence of a large proportion of carbonate of lime in their composition. The amount varies from 80 per cent. to 90 per cent. in the purer varieties, to as little as 30 per cent. in the very impure forms. Limestones differ largely in character and formation ; some stones are heavy, massive, and crystalline, whilst others are quite light and porous. British limestone is generally of the first type. Foreign matter is usually present in the stone, and the amount of this may vary from a small quantity to perhaps more than half the mass. Carbonate of magnesia is the most common foreign constituent so found, and stones containing about 40 per cent. of this mineral are termed dolomites or magnesium limestones. Oolitic limestones are formed of small egg-shaped particles cemented together with carbonate of lime. The colour of limestone varies in different quarries, but is usually cream or of a creamy tint, though some stones are blue-grey ; it should be uniform throughout in any particular stone. The colour is due chiefly to the presence of small quantities of oxide of iron or finely divided carbonaceous matter. The hardness of limestones

varies greatly: some are comparatively soft, and can be cut with a toothed saw and smoothed with drags; others require hammer and punch for working. Limestone, when compact, is tolerably free from defects other than colour, and in working the stone, good arrises and detail can be obtained. As a class they are less durable than sandstone, particularly when they contain clay as an impurity, and are very liable to be acted upon by the acids in the air in a manufacturing town. Limestone is completely destroyed by fire.

The best limestone is obtained from the Isle of Portland; it is also quarried in Somerset, Wiltshire, Devonshire, and Lincolnshire. Dolomites and magnesium limestones are obtained from Yorkshire, Derbyshire, and Nottinghamshire; good stone is also obtained from the north of France.

Ancaster Stone.—An oolitic limestone of which there are two beds: the Weather Bed and the Free Bed.

Weather Bed.—Colour, brown to grey; compact, coarse-grained, shelly texture; good arrises can be worked, and the stone weathers well; weight, 150 lb. per cu. ft.

Free Bed.—Colour, cream or pale buff; fine grained; works to a fairly smooth face; weight, 156 lb. per cu. ft.

Quarried at Ancaster, Lincolnshire. Used for general building.

Bath Stone.—Bath stone is a general term used for a number of stones quarried in the neighbourhood of Bath; it includes:—

Box Ground.—Colour, light cream; rather coarse grain; good weathering stone; weight, 129 lb. per cu. ft. Suitable for dressings and general building.

Coombe Down.—Colour, light cream; fine grained; weight, 128 lb. per cu. ft. Suitable for dressings, etc.

Corsham Down.—Colour, light cream; fairly fine grain; weight, 129 lb. per cu. ft. Suitable for dressings, etc.

Monks Park.—Colour, light cream; fine grained and fairly compact; weight, 137 lb. per cu. ft. Suitable for internal dressings and carving; well-selected stone can be used for external work.

Beer.—Colour, very pale cream; fine grained, compact but soft; takes a moderately fine arris; weight, 132 lb. per cu. ft. Quarried at Beer, Devonshire. Suitable for interior work and carving, unsuitable for exterior work.

Bolsover Moor.—Magnesian limestone; colour, yellowish brown; crystalline in structure; takes a good arris and weathers well; weight, 152 lb. per cu. ft. Quarried at Bolsover Moor, Derbyshire. Suitable for carved work, dressings, and general building.

Chilmark or Tisbury Stone.—Colour, buff to yellowish brown. The stone occurs in three beds: Trough Bed, Green Bed, and Pinney Bed. Even-grained stone; weight, 154 lb. per cu. ft. Quarried at Tisbury, Wiltshire. Suitable for dressings and general building; the stone weathers well except in polluted town atmospheres.

Clipsham Stone.—Oolitic limestone. Colour, buff to cream; medium to coarse grained; weight, 153 lb. per cu. ft. Quarried at Clipsham, Rutland. Used for dressings and general building.

Doulting Stone.—Occurs in two beds, Brambleditch and Chelynch.

Brambleditch.—Colour, cream; fine grained; weight, 125 lb. per cu. ft. Suitable for carving and interior work.

Chelynch.—Colour, pale buff; coarse grained; weight, 150 lb. per cu. ft. Used for dressings and general building.

Quarried at Shepton Mallet, Somerset.

Ham Hill.—Oolitic limestone. Colour, light yellow to light brown; coarse grained; weight, 140 lb. per cu. ft. Quarried at Norton-sub-Hamdon, Somerset. Used for facings, dressings, and general building in the neighbourhood of the quarries, but is not suitable for external work in towns.

Hopton Wood.—Colour, from light grey to brown; hard and crystalline; works to a sharp arris and takes a good polish; weight, 158 lb. per cu. ft. Quarried at Hopton, Derbyshire. Used largely for decorative work.

Kentish Rag.—Colour, greenish grey; compact and hard; takes a sharp arris, but is rather difficult to work; weight, 167 lb. per cu. ft. Chiefly used for rubble walling. Quarried at Allington, Kent.

Mansfield Woodhouse Stone.—Magnesian limestone. Colour, warm yellow; compact and fine grained; takes a good arris; weight, 146 lb. per cu. ft. Quarried at Mansfield, Notts. Used for fine sculptured work.

Portland Stone.—Oolitic limestone; it occurs in three beds of useful stone:

Roach Bed is coarse in texture, and suitable only for constructional engineering work.

Whitbed.—Colour, white to brown tint; takes a good arris and weathers well, suitable for all external building work.

Base Bed.—Colour, cream; fine grained, softer, and less durable than Whitbed; suitable for carving, and, if well selected, for external work.

Quarried at Isle of Portland, Dorset. Weight, 140 lb. per cu. ft.

Roche Abbey.—Colour, cream; fine grained, rather soft; weight, 139 lb. per cu. ft. Quarried near Bawtry, Yorkshire. Suitable for general building work.

Weldon Stone.—Oolitic limestone. Colour brownish; shelly, coarse, and moderately hard; weight, 150 lb. per cu. ft. Quarried at Weldon, Northants.

LIST OF SANDSTONES

Sandstone consists of consolidated sand held together by its own coherence or by iron oxide, carbonate of lime, silica, clay, etc.; in addition, it often contains mica. The stone may consist of grains of sand cemented together by lime or other material—the durability of the stone here

depends on the quality of the cementing material, as the sand is practically indestructible ; or it may consist of particles of calcium carbonate joined together by a siliceous cement, in which case the grains are likely to decay and the stone become porous. The most durable sandstones are those formed of grains of silica cemented together by silicic acid, with but a small quantity of other matter. A typical stone of this description is Craigleith, which contains about 98 per cent. of silica and only 2 per cent. of impurities. The grains in sandstones form the bulk of the stone ; quartz is the most common grain material, and this may be regarded as typical of all sandstones. The grains vary in size from the smallest particle to grains the size of peas, they may be angular or rounded, and their shape is a matter of importance.

Fine-grained stones are termed Freestones : they are easily cut and worked ; those with coarse, angular grains are known as Grits.

Conglomerate

Conglomerate is a type of sandstone in which the sand is replaced by gravel or shingle, cemented together with hardened sand, clay, or the other cementing materials mentioned.

The colour of sandstone varies according to the composition of the cementing materials, thus we have stones of colours respectively approximating to those of iron, clay, coal, and silica.

Sandstone is strong under pressure, and the best varieties weather well ; the fine-grained stones are suitable for carving and dressings, and the other types for all kinds of general building. These stones withstand heat fairly well, but under the action of excessive heat may either disintegrate or crack.

Sandstone is obtained from Yorkshire, Lancashire, Derbyshire, Cheshire, and other parts of England ; from Dumfries, Lanark, Forfar, etc., in Scotland, and from Glamorgan and Denbigh in Wales.

Bramley Fall.—Colour, light brown ; coarse grained, hard and durable ; does not take a fine arris ; weight, 163 lb. per cu. ft. Quarried near Leeds, Yorkshire. Used for engineering work.

Bristol Blue Pennant.—Colour, dark blue-grey ; fine grained and hard ; takes a good arris and face ; weight, 172 lb. per cu. ft. Quarried at Fishponds, Bristol. Suitable for general building work.

Closeburn.—Colour, light to dark red ; fine grained ; takes a fairly good arris ; weight, 124 lb. per cu. ft. Quarried at Thornhill, Dumfriesshire. Suitable for dressings and general building work.

Corsehill.—Colour, pink to red ; even texture ; takes a good arris and face ; weight, 141 lb. per cu. ft. Quarried in Dumfriesshire. Suitable for general building work.

Darley Dale.—Colour, light buff to grey ; hard, fine grained ; takes a good arris and weathers well ; weight, 148 lb. per cu. ft. Quarried at Bakewell, Derbyshire. Suitable for general building work.

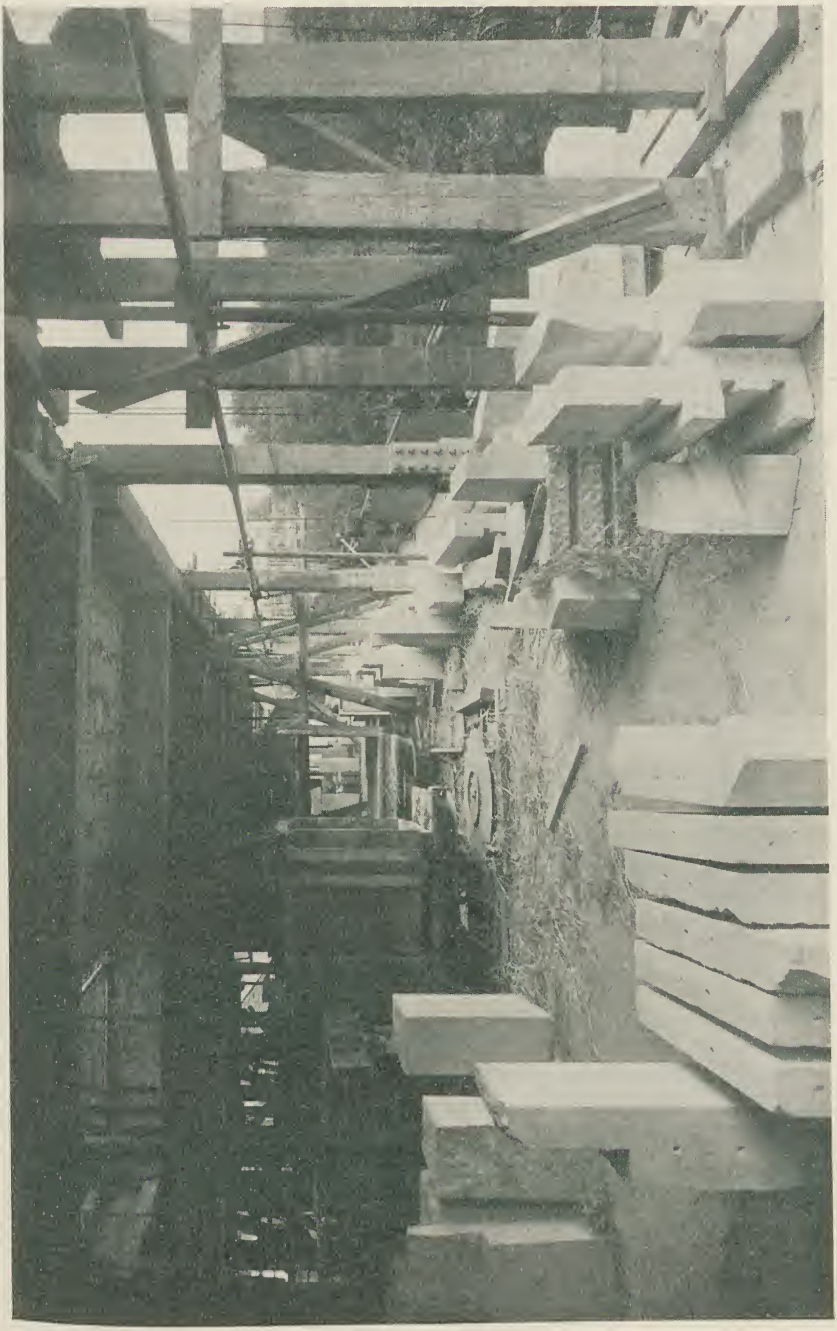


Fig. 14.—DRESSED STONES, NUMBERED AND PLACED IN A CONVENIENT POSITION FOR ERECTION AND FIXING IN A BUILDING

Forest of Dean.—Colour—there are two varieties, blue and grey; fine grained; weight, 149 lb. per cu. ft. Quarried in the Forest of Dean, Glos. Used for general building work.

Hailes.—Colour, light drab to light pink; fine and medium grained; weight, 144 lb. per cu. ft. Quarried at Slateford, near Edinburgh. Suitable for general building work.

Hollington.—Colour, red, mottled, and white; fine to coarse texture; weight, 135 lb. per cu. ft. Quarried at Stoke-on-Trent.

Howley Park.—Colour, light brown; fine grained; takes a good arris and a moderately smooth face; weight, 141 lb. per cu. ft. Quarried at Morley, Yorkshire. Suitable for monumental and general building work.

Kenton Stone.—Colour, light drab to light brown; fine and medium grained; takes a sharp arris and smooth face; weight, 142 lb. per cu. ft. Quarried near Newcastle. Used for dressings and general building work.

Park Spring.—Colour, light brown; medium grained; weight, 152 lb. per cu. ft. Quarried Yorkshire. Suitable for general building work.

Mansfield.—Colour—two varieties, yellow and red; compact and fine grained; works to a sharp arris and smooth face; weight, 140 and 143 lb. per cu. ft. Quarried at Mansfield, Nottinghamshire. Used for general building, but it is not durable in town atmospheres.

Robin Hood.—Colour, blue-grey; fine grained; takes a good arris and a fairly good face; weight, 145 lb. per cu. ft. Quarried at Wakefield, Yorkshire. Suitable for general building, durable when carefully selected.

MARBLE

Marble is a term applied to any limestone or dolomite which is sufficiently close in texture to admit of being polished. Many other ornamental stones are sometimes loosely called marbles, such as serpentine and alabaster. The durability of marble in a dry atmosphere or when protected from rain renders it a valuable building stone; on the other hand, when exposed to the weather or the acid atmosphere of large towns its surface readily crumbles. Marbles are uniformly crystalline, and have no bedding that would tend to make them fissile, they are entirely massive, and free from grain. Marble, owing to its beautiful marking, is largely used as a polished stone for internal wall linings and decoration, a purpose for which it is very suitable.

The chief English marbles are quarried in Devonshire and Derbyshire. Scottish marbles are obtained from Argyllshire and Sutherlandshire. A large quantity of the marble used in England is imported from the Continent; it is also quarried at Kilkenny, in Ireland.

THE RECONDITIONING OF OLD BUILDINGS

THE Housing (Rural Workers) Act of 1926 affords facilities to district and rural councils to enable them to assist in the reconditioning of cottages, and the conversion of buildings which would otherwise be condemned as insanitary and unfit for habitation, and so ultimately destroyed.

Money Grants Available for Reconditioning

The owner of such property may apply for a grant from the local authority up to two-thirds of the estimated cost of reconditioning, but the amount must not exceed £100 in respect of each cottage. To these grants, 5 per cent. of which is contributed by the Government, certain conditions are attached :—

(1) For 20 years after reconditioning, the cottage must be inhabited by persons of the agricultural labouring class.

(2) They must not exceed the normal rent of rural workers' cottages in the district, plus 3 per cent. of the owner's share of the cost of reconditioning.

(3) No assistance can be given in cases where the estimated value of the completed building exceeds £400, or where the estimated expenditure necessary to put it into order is less than £50.

Rural councils have found this Act of great assistance in getting old, insanitary cottages put into habitable condition, and it has also helped their own housing schemes by allowing them to obtain grants to recondition dilapidated property and to proceed to do this under Part III of the Housing Act of 1925.

The majority of rural cottages and farms which come under this Act have pronounced architectural merit, which it is of the greatest importance to retain. The Ministry of Health has therefore been at some pains to point out that reconditioning signifies more than just removing defective parts, and making good and watertight with the cheapest materials at hand. The spirit of the Act is to preserve, both internally and externally, the features of the old cottages as far as this is compatible with the higher standards of comfort and hygiene required by the agricultural worker to-day.

Survey and Plans

The first requirement for such work is to make a thorough survey of the building and its immediate surroundings, and to prepare a detailed

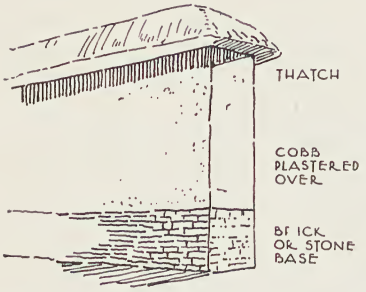


Fig. 1.—TYPICAL OLD THATCHED COB WALL

plan showing the work to be done. Most old cottages depend for their pleasing appearance more upon good proportions than upon ornament, and to alter the pitch of a roof or the height of a floor will often destroy the character of the building altogether. It is obvious that in many cases local by-laws cannot be complied with entirely in such work, but authority has been given to councils to waive these when necessary, and it is in the clauses governing the height of rooms that concessions are most often made. Rural cottages, standing as they usually do in the open, can be perfectly healthy although with much lower rooms than those of urban workers in built-up districts, and a low-pitched room with ample floor area can often be made livable by inserting a window for cross-ventilation. Under the Act the cottage must be "fit for habitation," and this implies chiefly freedom from damp, adequate lighting and ventilation, suitable and modern sanitary appliances, drains with proper sinks, etc., good general repair, a satisfactory water supply and washing accommodation, a well-ventilated food store, and sufficient space for preparing and cooking food.

The standard for new rural dwellings is :—

Living-room	. . . .	180 ft.	super floor area
1st bedroom	. . . .	150 ft.	,, ,, ,,
2nd bedroom	. . . .	100 ft.	,, ,, ,,
3rd bedroom	. . . .	65 ft.	,, ,, ,,

and although it is not always possible to reach this ideal, especially with regard to the third bedroom, every effort must be made in the plan to approach it as nearly as possible. One bedroom, at least, should have a fireplace, and the others permanent ventilators, either over the doors, or preferably to the outer air ; where possible a window should be provided on the staircase, and a more ample larder allowed for than in urban houses, the window of which should be covered with some fly protection. In some cases, where a row or several semi-detached cottages are to be restored, it is better to throw two into one and build extra new ones as needed, than to attempt to enlarge each separately to the required standard.

The first consideration is to make the building dry, and the three places where damp usually enters are through the walls, roof, and floor.

Walls

All solid walls will more or less absorb moisture ; the reason the inside of walls remains dry is because they are thick enough for the wet to dry

out again before it penetrates. In brick or stone walls the trouble may be through defective or decayed pointing. To repoint, the best material is a mortar made up of 1 part fresh-slaked lime, 1 part stone dust, and 1 part clean coarse sand. Another good mortar is composed of lias lime and sand in proportion 1 to 7 mixed dry, and this mixture then made up with water and Portland cement, in proportion 1 of cement to 7 of lime and sand mixture. The joints should be raked out to a depth of at least 2 in., and repointed with an ordinary trowel with a flush joint slightly cut in at the top. A coarse brush taken over the work the next morning will remove the newness of the repaired patches. In repointing it is important to see that the mortar is kept wet until the setting is complete, for if the work is done in dry weather old bricks and stone will suck the water out of the new pointing and leave it to crumble away into dust.

A stucco building should always be preserved, and neither rough-cast nor stucco plaster removed from the outside of old walls. If the repaired patches are unsightly it is a good plan to give the whole cottage two coats of limewash. Slake the lime in hot water, never cold, adding a little tallow or linseed oil and any colouring matter that is common in the district. This wash, when dry, will prove a very efficient damp excluder.

Cob Walls

These west-country walls are a mixture of puddled clay, stones, straw, and sometimes a little lime (Fig. 1). They are usually very thick, and remain sound as long as their faces are covered with lime rough-cast, and their lower parts protected from rain drippings from eaves. To repair these walls, restore any bare patches where the rough-cast has fallen away, and give two or three coats of limewash ; see to the eaves and gutters, and finally tar a plinth about 12 in. high all round the bottom of the walls.

Stone Walls

In stone districts, cottages built of local materials usually possess thick walls which have withstood damp well. If wet has penetrated exposed faces it can often be remedied by coating them with one or other of the stone liquids on the market. This will frequently be a good method of ensuring that the inside of walls which suffer from condensation remains dry. It is seldom of much value to render the inside of a damp wall with waterproof liquid or cement, unless the outside is also treated. There is always a danger of rot taking place

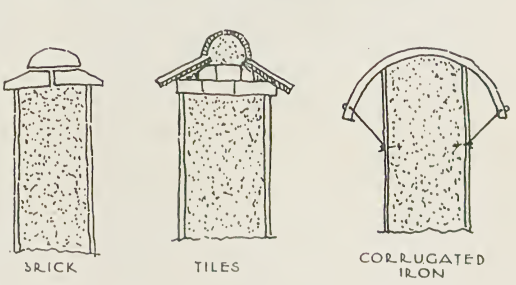


Fig. 1A.—THREE METHODS OF COPING COB WALLING

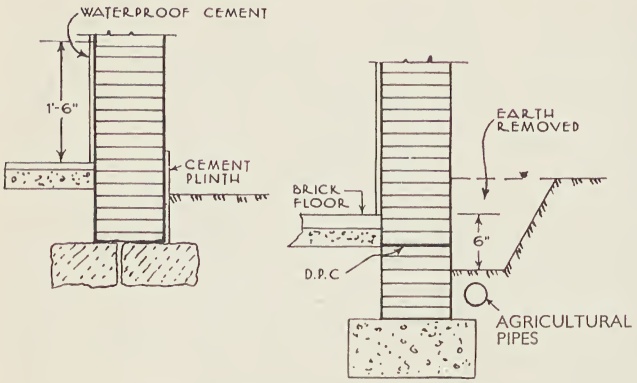


Fig. 2.—DAMP-PROOFING OLD WALLS

behind skirtings, or in timbers where the waterproofing cannot be applied. The body of the wall remaining damp will also cause heat loss and the room to be cold in winter, thus producing serious condensation trouble on the wall covered with the impervious solution.

Cottages in some districts were built with a thin ashlar face and rubble core, and the failure of this filling, which is caused through poor mortar being used in the construction, will be apparent by vertical cracks in the jambs at doors and windows. It is possible to repair this by means of grouting with liquid cement, but it is an expensive method, and if the damage is widespread will hardly be worth the cost of reconditioning. Bulging walls can often be saved by the erection of a buttress, and a little judicious underpinning may avoid the pulling down of a whole side of a building.

Sometimes old ashlar stone walls have been covered with plaster, which has become loose in patches. Before removing this a careful examination should be made, for it has often been the practice in the past to plaster a stone wall rather than repair the pointing. If the cottages in the district are mostly unplastered and the face below the plaster appears good, the whole may be removed and the wall pointed, otherwise it is probably best to cut out the loose or decayed patches and replaster.

Damp-proof Courses

Few old cottages were provided with damp-proof courses, and the lack is usually apparent. When the walls are wet up to about 3 or 4 ft. from the ground, the absence of a damp-course may be assumed. In brickwork or covered stone it is possible to cut a thin slit in the wall and insert a slate or other waterproof material, grouting it up solid as the work proceeds, which will of course be carried out in short lengths. If it proves impossible to cut the walls in this manner, the damage may be reduced by providing externally a waterproof cement plinth, and plastering the inner face of the wall some 18 in. high with a waterproof plaster of cement and " Pudlo " or similar waterproofer. The external rendering should be carried down below the floor level. Around many old cottages the ground level has risen, and this earth must be removed to at least 6 in. below

the floor line, by making either a sunken area or a sloping bank (Fig. 2). In the former case the area must be drained with gullies to soakaways. A further precaution is to lay agricultural drains round the cottages, especially if they are on sloping sites. These will cut off and divert any natural springs, while helping to keep the immediate ground near the walls dry.

The Knapen system of inserting clay tubes in a wall, sloping outwards, to draw off the water by capillary attraction, is a Continental method which has proved successful in many cases.

Flint Walls

This is an imperishable material, and decay occurs only in the mortar filling. Repairs really consist in replastering the wall, first removing the decayed portions and resetting the flints in the new plaster. Flints used in cottages are generally round, or roughly broken to expose the black face—knapped flint work with joints so fine as hardly to be visible is confined to better-class work. When the plastering is completed the appearance will be improved if the faces of the exposed flints are cleaned of all traces of mortar with a rag.

Rubble Stone Walls

The following are some difficulties peculiar to the treatment of these walls. The general crumbly nature of the surface will cause the new plaster to pull away. The excessive suction of dry rubble walling can seldom be prevented even by means of the most generous wetting ; the mortar must therefore possess a high water-retaining capacity, which can be provided by using grey-stone lime. On the other hand, flints have no suction, and depend for good results on the keying of the plaster. The mixture should have sand not too loamy in quality, and the following compound has been found satisfactory : 1 cement, 3 white hydrated lime, 8–10 sand. It must be used immediately, any left over thrown away and fresh made after two or three hours. The best time to do the work is in spring or autumn, as both wet and dry weather tend to prevent the proper setting. A rubble wall so treated should be finished with a wood float.

Half-timber Work

The renewal of decayed first-floor beams in old half-timber construction is not always easy (Fig. 3). Where the first floor oversails, the construction of the angle of the building is usually as Fig. 3A. The dragon beam is pinned to the main cross-rafter as well as to the stout angle-post below, while the oversailing floor joists are pinned radially into it at one end, and rest on the head of the floor structure at the other. The use of this method can almost always be seen from the outside, for the projecting portions of the joists are not exactly parallel to one another,

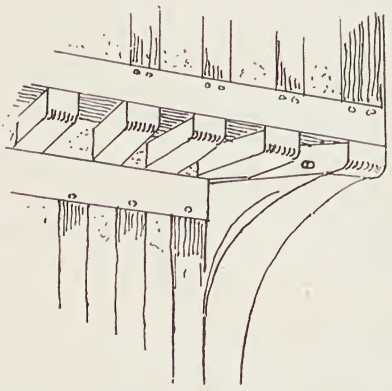


Fig. 3.—DETAIL OF ANGLE POST OF OVERSAILING FIRST FLOOR, USUALLY CUT FROM ONE PIECE

but tend to slope towards the angle. The renewal of these short floor joists is not difficult, but if the dragon beam itself is decayed the whole of this portion of the floor will probably have to be taken out.

Where the plaster has fallen away between the timbers, the work of renovation is difficult. The old method of applying many thin coats to the laths, and allowing each to dry before the next was put on, is too slow for modern practice. One of the best methods is to fix expanded metal lathing between the main timbers in front of the laths, and to use a mix, suggested by the Building Research Station, of 3 parts lime putty to 1 of Portland cement. One part of the combined mixture to be used with 2 to 3 of sand. The danger spots in this type of repair are the joints between wood and plaster, where cracks may occur as the plaster dries, but the fillets used for the laths and expanded metal will probably be sufficient to prevent rain from penetrating. A last resort, where the walls are in a bad condition but the main timber structure remains sound, is to nail battens and tile hang the whole cottage, or cover the exterior with elm boarding.

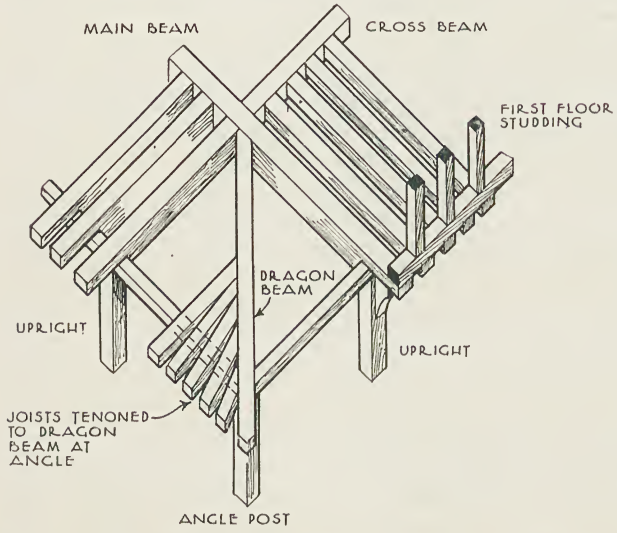


Fig. 3A.—METHOD OF CONSTRUCTING OVERHANGING FIRST FLOOR IN HALF-TIMBER COTTAGE

Chimneys

Chimneys are another source of damp, often being defective where they pass through the roof, or carrying damp down from the extended faces into the rooms below. If it is possible to insert a damp-course just above the roof flashing, a cure will probably be effected. The stack itself should be pointed, but the provision of pots or other coverings at the

top where none exist may lead to smoke trouble. Many old chimneys have projecting bricks stepped just above the roof line; these drips should never be removed, and where decayed should be replaced, as they are of the greatest assistance in keeping out the wet (Fig. 4).

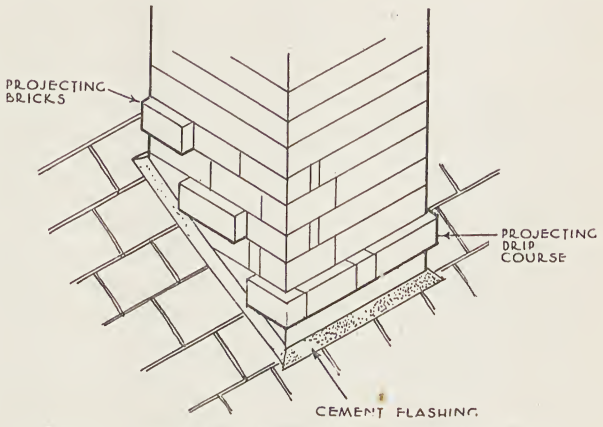


Fig. 4.—WEATHER PROTECTION TO CHIMNEY STACK

In repairing the large external chimneys of the chimney-corner type, great care should be observed to retain all the old features, some of which may at first appear unnecessary. Many of these old chimneys have established a sort of equilibrium by trial and error in dealing with the smoke, and the slightest alteration may cause down draught and a smoky room. The usual features to be noticed are the slightly raised hearth and the height between this hearth and the chimney beam over; this latter is frequently about 4 ft. 6 in., and to raise it will almost certainly cause trouble (Fig. 4A). The beams are often splayed on the inner side in the centre, and the brickwork above set back about 1 in. from the inner face before corbelling in to form the chimney dome. If a new beam has to be inserted it should conform to these or any other peculiarities of the old one. Again, the back of the fireplace frequently has a recess about 3 ft. wide extending up into the chimney, but stopping short of the hearth by about 12 in. The blocking of this apparently useless recess, or cutting it down to the bottom, has, in the author's experience, caused the chimney to smoke, but the trouble ceased when the old arrangement was reinstated. In no case where an old open fireplace has a straight flue should a bend be inserted—it may prevent a certain amount of rain coming in but will almost certainly prevent up draught. Most cottagers burn wood in these open fires, and the lazy smoke needs space to be carried up by the rising warm air.

Roof Coverings

The repair of old and leaky roof coverings requires much care, and it may be said that wherever possible the work should be done in similar materials to the existing. Thatched roofs often need no more than a thin coating of new thatch about 6 in. thick; on the other hand, long-neglected roofs, where ash saplings have been used in place of battens and become decayed, should be re-thatched, for good wheat-straw thatching has a life

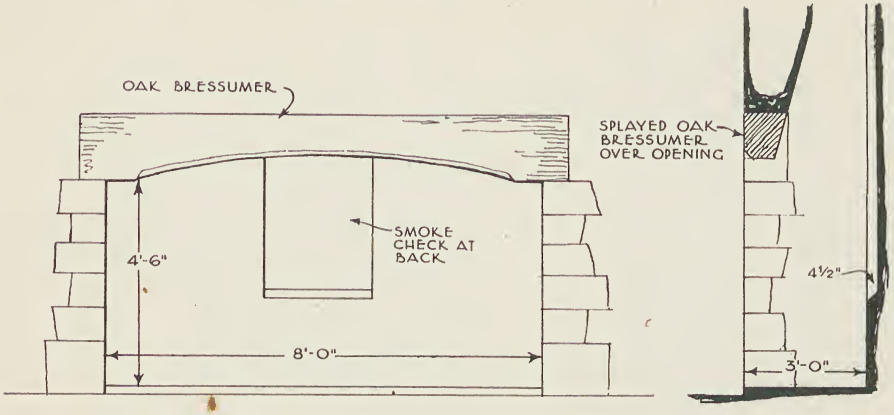


Fig. 4A.—ELEVATION AND SECTION OF OPEN FIREPLACE

of some 25 years, but on no account should bruised straw which has been through the threshing machine be used. Reed thatching is more lasting than straw, and is used in districts near marshes where suitable rushes grow in large quantities. The ridges must still be of straw, but as reeds last longer than straw new ridges can be put in when needed.

This work is a specialist's job, each district making use of its own methods, and it is therefore of little value to go into detail. The main points to observe, however, are the use of good, well-tarred hemp twine for tying the bundles in place, and to ensure that little more than the ends of the thatch should show after the work has been trimmed off with the thatching hook. If the work is well done no straggly pieces should be exposed anywhere to tempt birds to begin pecking out the straw. Thatch can be treated in alum water before laying to render it fireproof for a considerable period, and unless the cottages are near railways or main roads local councils will have no objections to raise over the use of this material. Where only the lower portion of thatching at eaves has perished it may be removed altogether, and several courses of plain tiles substituted instead of re-covering the whole roof.

Tiles and Slates

Defects in these roof coverings are caused either by the decay of the laths on which they are laid, or through the failure of the nails or pegs with which they are secured. If the former is found to be the case, the roof should be stripped and new lathing laid. It is unlikely that the old rent lathing can now be supplied economically, and there is nothing against using modern sawn laths, but it will be an additional precaution against weather if some form of bituminous felt is laid over rabbit wire underneath them. The use of rabbit wire is recommended to prevent the felt sagging between the rafters, for this material will tear and its object

be nullified. Old tiling is sometimes found bedded on hay, which should be removed, as it rots with wet, and falling on the ceiling joists below causes damp patches to soak through the plaster.

In laying new roofing, the tiles should have a lap of not less than 4 in., and be secured by pegs or nibs. Old tiling is without nibbing, and when re-used should be provided with new oak pegs. Old tiling is also frequently bedded in lime and hair, and if this practice be repeated it is important to dip the tiles in water before laying to prevent them absorbing water from the plaster, and so keep it from setting. It is seldom advisable to board the roofs over the rafters, as this makes a rigid surface. This rigidity will give trouble later, for the old rafters have taken their position after long years of use and have a certain elasticity to wind pressure that prevents the tile or slate covering from snapping.

Substitution of Modern Materials

Where the cost of old local materials, such as stone slabs or green slates, is prohibitive, substitutes should be chosen that do not disfigure the district. Blue or purple slates are seldom satisfactory, and various greys are available, especially the " seconds " from the neighbourhood of Delabole in Cornwall. In place of stone slating, duncoloured plain tiling is often suitable, and asbestos tiles can now be had in dark colours which are far better in appearance than flaming red machine-made pressed-clay tiles that will never weather or tone down. On all types of roofs the ridges and hips must be of similar colour to that of the general roofing.

On outbuildings economy may sometimes dictate galvanised iron, and this is not to be condemned if painted with a dark grey oxide paint or covered with bitumastic. The sheeting should be painted both sides, as condensation will take place on the under side if the bare iron is exposed.

Pantiles

Pantiles have little to recommend them except appearance (Fig. 5), and if the roof is leaking the best method is to strip and relay with plain tiling. Many old roofs have the pantiles laid over reeds set horizontally between the battens, on which mortar fillets are placed vertically under the joints of the tiles. The reeds tend to pick up the damp and prevent it dripping on to the ceiling below. A cottage with a pantile roof of a steep pitch may be found on examination to have had a thatch covering removed and replaced by tiles, and if the roof timbers show signs of sagging under the extra weight it is better to replace the thatch than to go to the expense of strengthening the rafters.

Flashings

Lead is seldom used in flashing old roofs, and where the verges at gable ends or sloping roofs abut against a wall the tiles are given a tilt upwards to throw the water away from the weak place. Valleys between

two roof slopes are swept, as are the roofs of dormers, but it is not possible to do this to the cheeks, which are seldom found tiled, but are usually boarded or plastered, and this practice should be followed in reconditioning (Figs. 6 and 7).

Gutters, etc.

Gutters and down pipes must be cleaned out and kept clear. Much damage and dampness in old cottages is due to the absence of gutters, and too small a projection at the eaves, which allows the drippings to splash up from the ground.

Half-round gutters with suitable gutter brackets should be put to all roofs, and the down pipes fixed about ½ in. clear of the walls. Where there is difficulty in fixing the gutter brackets to the rafters or eaves board they can be attached to the wall, and the gutter held on a species of cantilever in a position just below the eaves where it will catch the drippings.

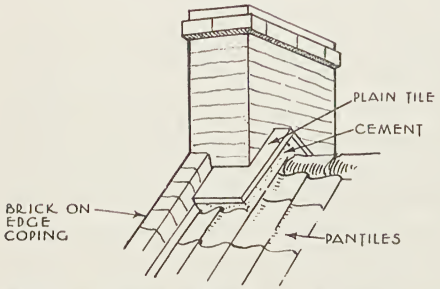


Fig. 5.—SIMPLE METHOD OF FLASHING A CHIMNEY STACK IN PANTILED ROOF

On thatched roofs ordinary gutters are usually impossible to fix, and owing to the eaves having a wide projection they are usually omitted, provision being made at ground level to prevent splashing the walls and for carrying off the water as already described. A good substitute for ordinary gutters is one of tarred oak boards framed in the form of a V-shaped trough, and well pitched inside. Wooden down pipes can be taken from outlets in these wooden gutters to discharge over gullies or into rain-water butts.

Rain-water Storage

Rain-water butts must also have provision for carrying off overflows to some distance from the building, as such a butt without an outlet is a danger, the seepage of the water trickling under the wall and causing damp. Butts must stand clear of the walls, for a leaky butt will cause a damp patch to appear in the wall behind it, and as this is often the first indication of a hidden leak much damage will have been done before it is discovered.

Floors

Old cottage floors of brick and stone were frequently laid directly on the earth, and are permanently damp, especially in the winter, when the warmth draws up the moisture. They should be taken up, the earth excavated, and a layer of concrete spread from wall to wall. The flags

or bricks can then be laid and jointed in Portland cement. A better method is to remove the stone floor entirely, lay a damp-proof course over the concrete, and a wood-block floor to the room, or, if a cheaper scheme is necessary, creosoted battens may be laid in the concrete itself, the whole floor then given a coating of bitumen, and floorboards nailed to the battens. These floorboards should first be creosoted on the under side as an extra protection against rot. Elm is a wood not often enough used in country districts, and elm boards seasoned for several years make an excellent floor which will take hard wear. A good paving for out-houses or sculleries is one of bricks laid in sand, and such floors may often be so dealt with without the cost of laying concrete.

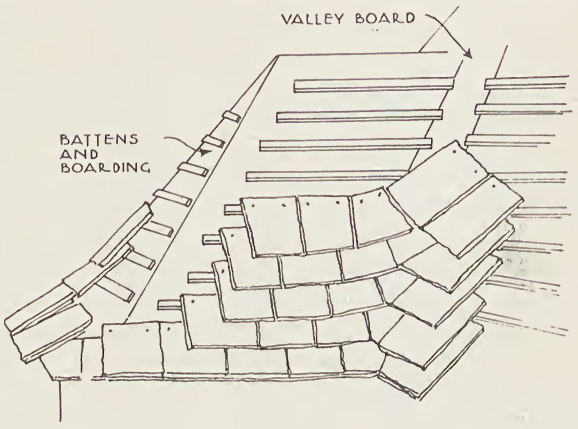


Fig. 6.—SKETCH OF LACED TILING TO VALLEY IN PLAIN-TILED ROOF

In many cottages, partitions are made of elm boards covered at the joints with fillets. This is a picturesque but not a good form of partition for bedrooms, and the Ministry of Health recommends that no wall should be single-boarded. Some form of plaster-board partition should be added, but it is better to replace with a stud partition, for these old elm partitions are frequently attacked by worm which, if not checked, will extend to other woodwork. In all cases where not removed they should be treated with a formaline wash, a treatment that should be extended to all old

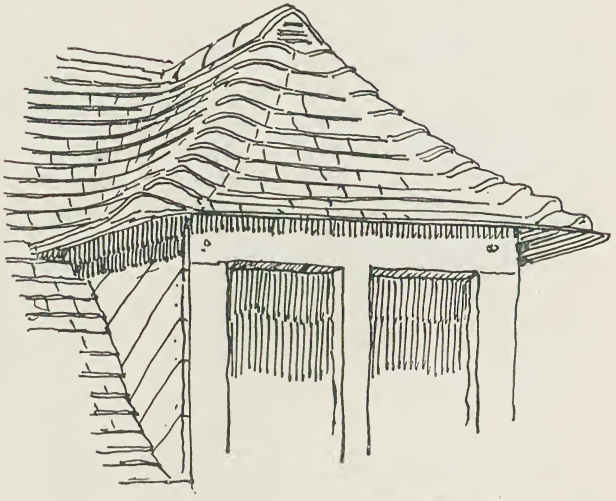


Fig. 7.—DORMER WINDOW WITH BOARDED CHEEKS AND SWEPT VALLEY

The hips are covered with bonnet tiles.

woodwork showing wormholes. When new timbers are inserted they should be given a coating of Solignum to preserve them from attacks of worm, for this pest often lies dormant until new wood is inserted, when it begins a fresh attack, especially on beam ends built into walls. If a new ground-floor partition is inserted on a solid ground floor, the best method is to lay a concrete plinth, with a damp-course on the top, and bolt the cill of the new partition on to it.

Timber beams which have rotted at the ends need not be discarded. The usual practice is to shore up, cut out the rotten wood, and scarf and bolt on a new timber end. Another method is to build into the hole from which the rotten beam has been taken two angle irons or a length of channel iron wide enough to take the beam, which rests in it with its end about 6 in. clear of the wall. This is drilled and secured with two $\frac{3}{4}$-in. bolts taken through it and the channel, and made fast with plates and washers (Fig. 8). If the iron supports are tamped into the wall tightly with concrete, this is a satisfactory and economical repair.

Roof Construction

Failure of the structure is generally due either to :—

(1) Drift.
(2) The removal or cutting of some vital part of the structure.
(3) The decay of the material composing the members.

Drift is the deformation caused by some force set up in the framing of the roof timbers which is not resolved or counteracted. The roof is what is called an unstable structure, and little by little will thrust upon the walls until after a lapse of years it gives way. Most old roofs are theoretically unstable, but the builders used such enormous timbers that the margin of safety is very large. For this reason, also, many decayed roof timbers are still standing, and if the beetle or worm which has eaten them away is dead, the timbers are still strong enough to support the roof.

Coupled roofs were often erected without any kind of tie, and the wall plate may be found pushed nearly off the wall. In repairing such a roof a collar, set as low down as possible, should be inserted to every fourth pair of rafters. Boards nailed to rafters which have no ridge piece, but are halved and pegged together, will do much to steady them, and the fact that they are already out of upright does not much matter. Any attempt to straighten them will do more harm than good.

Braces are often missing in braced-collar roofs, and these should be replaced, with any missing struts (Fig. 9), on the inner face low down at the foot of the rafter. These roofs frequently have a double wall plate, the main rafters resting on the outer and the short struts on the inner (Fig. 10). The two wall plates are connected together at intervals by cross-pieces halved to them, and this tends to spread the bearings on old, thick, rubble walls.

When roofs fail through decay it is nearly always because of fungus (dry rot) or beetle (the death-watch). The only way to eliminate the former is to remove and burn, but a corrosive sublimate may be used with extreme care to kill the beetle grub. It is, however, a deadly poison. A liquid formed of sulphur dioxide and camphor has been used with success on roof timbers against this pest.

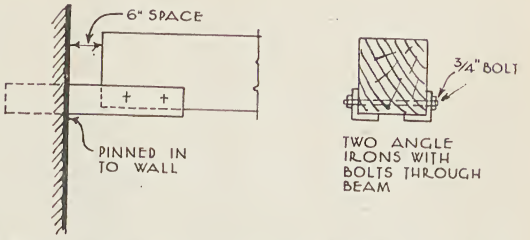


Fig. 8.—REPAIR OF BEAM DECAYED AT WALL

Doors and Windows

Doorways are often low, seldom higher than 6 ft. 6 in., and wide in proportion. This height is sufficient for the average man, and if the doorway is arched is necessary only in the centre. Trouble with cottage doors which lead directly into the living-room is mostly due to exposed situations. The wet drives under the door, but can usually be excluded by a weather bar in the cill, and a properly arranged weather mould on the lowest rail. If feasible it is often worth replanning the entrance on a less exposed side of the building, or failing this to provide an external porch. If the door itself is defective a new one should be made of the same pattern ; modern stock doors, which are suitable for urban houses, are utterly out of place in rural cottages.

Wet will penetrate through windows, either between the wall and frame if there is a straight joint and no reveal, or through badly closing sashes. If the area of the window is insufficient for the room it is often wiser to insert a new one and leave the other undisturbed. In bedrooms, new windows placed in gable ends are better than an attempt to enlarge the small lights under the eaves. To prevent rain driving in through the joints it is often sufficient to put a tile creasing or lead drip over the head and to point the joints in mastic, or, if the character of the cottage allows it, to put a wood architrave all round the outside.

Old Mullioned Windows

Old mullioned windows usually have a distance of 14 in. between the mullions, and the existing width should never be altered ; it is better, in fact, to add additional lights if the window must be enlarged, but extra height can often be added without detriment. The only satisfactory method of dealing with decayed limestone mullions, short of renewal, is to apply a coat of good oil paint in the summer, when the stone is dry. Before treating, the stone should be washed to remove soluble salts, and allowed to dry before painting. There are a number of paints on the market which will give the appearance of stone and are very durable.

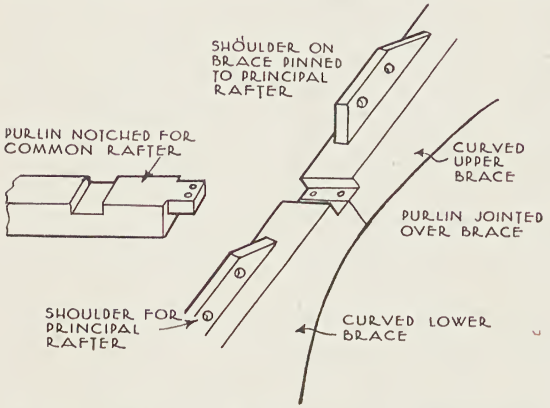


Fig. 9.—SKETCH OF BRACED ROOF CONSTRUCTION

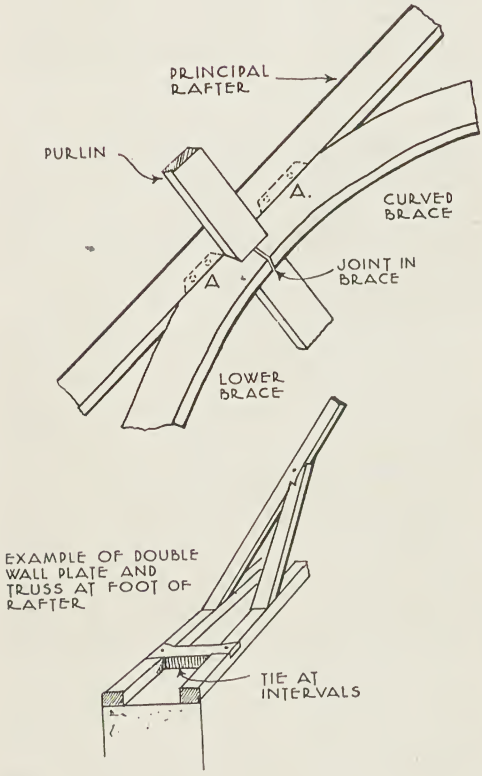


Fig. 10.—

If the braces are missing, a notch will be seen above and below the purlin in main rafter.

If a transome is inserted, the upper light should never be a square, and a good proportion is to make the upper light the same as the lower, less the thickness of the transome (Fig. 12). Sash windows divided into squares with glazing bars may often be enlarged by adding another pane in width, but this must be done carefully, as these windows, if too wide in relation to their height, will bind on opening and shutting.

Wood lintels that have decayed should be removed and replaced with reinforced concrete, which can be pressed into irregularities and therefore does its own keying up. The rods should be kept close to the under side of the concrete, with about $\frac{1}{2}$ in. cover on the under side, and turned up at the ends.

Iron casements may be set in wood frames or stone mullions, but the modern combined iron sash and frame of standard dimensions is usually unsuitable in a reconditioned cottage.

Water Supply

Most rural water supplies are from wells. A careful analysis should be made of all well water, and is best done at the outset, as it is obvious that no cottage can be certified as "fit for habitation" without a pure and suitable water supply. This analysis should include information as to the depth of water in winter and

Fig. 11.—RENOVATION OF AN OLD FARM-HOUSE

Cutler's Green Farm-house, Thaxted, Essex, showing it in its original dilapidated condition and, in the lower picture, after renovation and extension. The one extraordinary feature of the building was that the central portion was roofed diagonally. The hips, therefore, come down to the middle of each face of the building. In extending, the alterations were planned so that this principle would be maintained, and the ridge is therefore at 45° with the main axis of the building. Reed thatching was substituted for soft straw. The central chimney stack was added to after underpinning, and the separate stack was treated independently. (*Architect: Thomas Rayson, F.S.A., F.R.I.B.A.*)

summer, as well as records, if any exist, of the condition of the water in abnormal seasons of drought. Sometimes it happens that a group of cottages draw water from a common well, and it should be ascertained that this is a right exercised by each cottage irrespective of ownership. It can happen that the well is private property, and that the owner on selling the freehold of a cottage does not convey the right to draw water from his well.

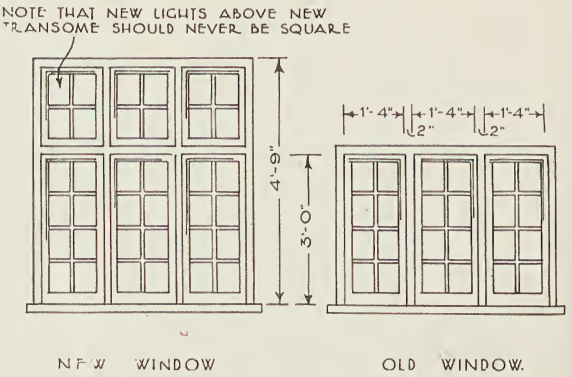


Fig. 12.—ENLARGEMENT OF OPENING

Where possible, each cottage or pair of cottages ought to have its own well, of sufficient depth to avoid risk of pollution. Wells should be steined to a depth of about 12 ft. with 9-in. brickwork, and be provided with a pump. Open wells are always liable to pollution from refuse being thrown into them, and the tops should be covered with concrete sloping away from the mouth. An iron door, bolted and padlocked, should be provided to obtain access to the well if repairs are required.

Sanitary Conveniences

If sewers are available there is no difficulty in arranging for these, provided there is an ample water supply laid on. An ordinary w.c., with a water-waste-preventing cistern, either inside or outside the cottage, is all that is required. In the former case it should never open out of a living-room or scullery without a ventilating lobby.

An earth-closet is suitable where water is scarce, but must always be entered from outside the cottage, and a covered way to it is an advantage. Earth-closets must be properly lighted and ventilated, and provision made for the removal of the pail through a hatch ; there must also be sufficient garden round the cottage to allow for the disposal of the refuse.

Where no drainage system exists the water-closet may be taken to a septic tank. The use of cess-pools should be discontinued, as they always prove unsatisfactory in the long run, even when facilities for emptying are available. A simple septic tank system may include a number of cottages, as it is less expensive to deal with several drains in one.

Bath and rain-water should be collected and taken to separate soakaways so as not to overload the drains, and these soakaways should always be away from the cottage on the lower slope.

"VETTING" A PROPERTY

IT has been said that the most severe test to which an advanced student of architecture, or, for that matter, building, may be put is that of instructing him to " vet " a house and to advise a prospective purchaser. There is probably no branch of the architectural profession so obscure to the student and so seldom approached in his training. Experience alone can produce the perfect " vet." A client may have set his heart on a house, and have convinced himself that it is his dream come true—he invites you to " vet " his gem, partly with an air of pride in his successful find, and partly because he thinks that you, the expert, will be able to endorse his choice and to give him that little bit of extra self-confidence he needs to close the deal.

Careful Consideration Needed

Now, to commit oneself as an expert to the extent of advising a purchase at a given price is an important step. One's reputation is made or marred by this, and advice given, which is later proved to have been wrong, will never be forgotten or forgiven. On the other hand, an adverse report with full substantiation would be safe but, unless tactfully put, might leave the client dissatisfied.

The windows or doors or interior finish, or the style of the property generally, may be of a type which you personally detest, your pet aversion or what you will; but your client, who is not an architect, does not see things as you do, and it is you who must strive to see as your client sees, but with that extra power of " X-ray " to discover that which to him is hidden. Always remember that you are engaged for the purpose of correcting and substantiating your client's choice, and not to give a lecture or report on good and bad taste.

Find Out Your Client's Requirements

A client's first inquiry should be followed up with a discreet and detailed investigation into the exact scope the required report is to take. It is not likely that he will have a clear-cut idea on this matter, but will be quite open to suggestions from you. It is this preliminary study of your client's views which it is so very important to have at the early stages, and before you get to work. Having secured definite instructions and all possible data, it is perhaps preferable to commence with the legal points as far as they concern the property deeds.

Commence with Legal Points

Is the property freehold or leasehold, are there tithes or ground rents, restricting covenants, and if so, to what extent does their influence go? Make notes of any easements or restrictions which would call for investigation when the survey on the site is proceeding.

It may be that included in the conveyance are certain restrictions which would prevent your client from carrying on some scheme of business or undertaking which he contemplates.

Examine the title generally, and make sure it goes back for a sufficient number of years uninterruptedly.

If alterations and additions are contemplated, be sure that such may be carried out without infringement of the rights of adjoining owners, such as rights of light and air, and that such alterations and additions may be carried through to the requirements of the local by-laws and building restrictions.

Find to what extent any road-widening scheme is likely to affect the property ; how the area is scheduled or zoned by the town-planning authorities, and by the Ministries of Health and Transport.

If a local authority or private owner contemplates the construction of some undesirable plant or works, such as sewage treatment or industrial project, attention should be drawn to this.

In the case of house property which it is proposed to convert into flats of offices or shops, make discreet inquiries into the possible restrictions or opposition to such a scheme by either local authorities or adjoining owners. Such restrictions may exist even in the case where the property is freehold.

Look up any existing plans of the property, or photographs, and, at the completion of such investigations as have been outlined above, you might proceed to the real part of your commission, the actual investigation of the property.

The advantages which will have been gained by making the foregoing investigations prior to visiting the site are twofold. First, you have had the opportunity of discovering precisely what your client's requirements are without being prejudiced or influenced in any way by your own judgment; and, secondly, having obtained a clear and definite idea of his requirements, you are less likely to present to him a confused and extensive list of merits and demerits which will be so overwhelming that it is impossible for him to see the wood for the trees.

CARRYING OUT THE INSPECTION

Being in the vicinity of the site, one should note the physical features of the surrounding country : if rural, the lie of the site—is it liable to flooding ? sheltered on the best side ? what is the subsoil ? is it a damp or unhealthy district, or high, breezy, open, and healthy country ?

The Surroundings of the Property

If in the town area, is the property well back from the road, free from undue traffic noise or vibration ? The frontages—are they long, ill-kept, dangerous boundary walls or trees ? if a long frontage to important or established roads, what are the possibilities of development as a building site ? Note the surrounding properties—is there an undue proportion of empty property in the vicinity ? if so, try to find the reason. Is the district an improving or deteriorating one, and what are the reasons ? Now consider the possibility of developments by adjoining owner or owners which may lower the property value. Are shopping and transport facilities efficiently near (or agreeably remote) to be handy and not to deter ? Other matters of concern at this stage of your investigation are the facilities for recreation—golf, cricket, tennis, fishing, hunting, cinemas, theatres, etc.

Condition of the Grounds within the Property

Having obtained satisfaction on the matters relative to the environments of the property, take a quick look round within the gates, the garden first : what is its condition generally—as a gardener would see it, as a setting for the property, and, most important of all, as your client will see it ?

Is the soil rich, or impoverished ? are plants and trees mature ? what is the saturated water level? and what are the possibilities, if non-existent, of adequate drainage in wet weather ? Are the grounds planned, or do they just ramble without evidence of design ? View the kitchen garden ; the outbuildings, yards, and quarters generally : what is the general impression obtained on probable dilapidations, and essential alterations to make them efficient in use, hygienic, and generally workable ?

Preliminary Look Round

Continue with a brief run round the property, and finally through it ; try to assess the degree of spaciousness and simplicity or otherwise of the rooms, and their access. Think of aspect and view from the principal rooms, as well as lightness, airiness, and loftiness. Are the floors level through, with passages, corridors, and landings at each floor level, or is there a step in or out or up or down where least expected ?

Do not be conscious only of defects and, in consequence, fill your mind with ideas of how *you* would have avoided them ; find the possibilities and, above all, keep in mind your client's requirements and not your own reactions.

Take a good look through the cellars, and make a similar inspection of the lofts or the roof voids. To an experienced architect there is no better evidence of the class of work a builder has maintained than is

exemplified in his cellar and roof void construction. These important parts of a building are seldom subject to alteration after completion, unless through some structural defect, and in the case of the loft or roof void it is most likely that the last person to enter and leave it was the builder, and the evidence of his work remains without interference.

Now that the preliminary look round is completed, and a general idea of the features of the property is grasped, it is opportune to commence one's thorough investigation, on a preconceived plan.

In the following " vetting " schedule, it is necessary to include many items which cannot all apply in any one case. The points for investigation are grouped under headings, and it will be found convenient, in the general case, to follow through in the order given, omitting that which does not apply in the particular case.

A USEFUL " VETTING " SCHEDULE

The purpose of a " vetting " schedule is to call to mind the facts and features to be examined. However good one's memory may be, however experienced or adapted one may be to this work, it is essential to make notes on all important points in order that nothing be overlooked or forgotten. The schedule should be checked off before leaving the site, to avoid the annoyance of a second visit to " clear up " the points overlooked.

The list on page 389 is a schedule of the features that will generally require to be examined. Pages 392-3 give a schedule for use in " vetting " a small house; pages 396-7 a schedule for a large house; and pages 402-3 a schedule for " vetting " business premises.

THE " VETTING " SCHEDULE EXPLAINED

Services—Roads, etc.

Items under (3). Roads, lanes, footpaths, and bridges should be briefly described, and any particular or unusual features that are noticed, recorded. It sometimes occurs that a property is inaccessible by road at certain times owing to flooding, or level crossings, or suchlike. Existing footpaths may restrict developments or destroy the seclusion which would otherwise exist.

Water Supply

The water supply must always be considered, as the sources and the services in this country are far from satisfactory in many places. Some authorities, generally in hilly districts, rely on an artesian well for emergency supply, and hill reservoirs for general supply. In such cases it may often happen that following the change-over from well to reservoir for the supply, the hardness of the water changes from some

"VETTING" SCHEDULE

(1) PRELIMINARIES.—Agent, solicitor, and/or owner concerned. Terms of sale (or lease). Terms of conveyance, restrictions therein, title easements existing, rights of way and light, ancient lights.

GENERALLY

(2) PHYSICAL AND GEOLOGICAL.—Situation, altitude relative to immediate surroundings, general setting of property, both physically and geologically. Soil and subsoil. Class of neighbourhood. Approaches. Garden paddocks, fields, parkland, etc. Boundaries and brief description of adjacent properties.

(3) SERVICES.—Roads, lanes, footpaths, bridges, etc. Water supply and source. Electric supply and source; gas, telephone, possibility of good wireless reception. Soil drainage, land drainage, rain-water drainage (farm drainage), if existing, considered separately.

(4) AMENITIES.—Shopping facilities, transport, by road or rail, sports such as hunting, fishing, shooting, golf, cricket, etc.

(5) THE BUILDING EXTERNALLY.—Collectively: period or periods of construction, extension, or reconstruction. Architecturally. General distribution of buildings from points of view of planning, aspect, orientation, and adaptability and practicability.

(6) STRUCTURALLY.—Chimneys and pointing, roof flashings, slating, tiling, flats, porches, and hoods, and skylights, lantern lights, dormers; then condition of eaves gutters, cornices, parapets, and damp-proofing to same.

Walling, and finishings, such as pointing, rendering, hangings, etc. Window and door reveals externally, head construction, arching, or cantilevering. External wall construction and thickness. Ventilation, damp-coursing both horizontal and vertical. Plants, trees, or shrubs, too close. External plumbing, cracks in walls, settlements, bulging, cracking or disintegration of isolated bricks or stones, slates, tiles, etc.

Steps, thresholds, pavings, flower beds, and creepers. State of metalwork externally, also woodwork of structural importance. Floor cavity and underfloor ventilation. Paving and path drainage, gullies, grids, channels, falls of ditto and general workability. Floor levels in relation to external ground or paving levels.

Glazing, general external decorative repair.

Dilapidations.

(7) INTERNALLY.—Planning, distribution, and accommodation. Lighting and ventilation, relative floor level, staircases. Floor finishings, walls and wall finishings, ceilings and ceiling finishes. Size of door openings, borrowed lights, and relative area of windows to floors. Structural timbers, particularly in floors and roofs, or walls if half-timbered. Interior of dormers, fanlights, skylights, windows, doors, porches, balconies, flats, and roofs. Condition of skirtings, and wood floors under sinks, etc.

Timber disease and pests, dry rot, beetle, etc.

(8) SERVICES INTERNALLY.—Electric and gas service, hot- and cold-water services, heating and boiler arrangements, cooking appliances, mantles, grates, ranges, and fireplaces. Bells.

Sanitary fittings, connections, ventilation, and plumbing design.

(9) INTERNAL DECORATIVE REPAIR.

(10) DILAPIDATIONS.

(11) LANDLORD'S AND TENANT'S FIXTURES AND FITTINGS.

(12) CONCLUSION.

16 degrees of hardness to almost nil, being the difference in the two supplies. This is annoying to domestic users, and fatal to some industries.

The size, condition, and pressure of the supply must be obtained. The condition of stop-cock and run of supply pipe within the boundary.

The position, nature, capacity, and condition of the storage tanks must be proved.

In old properties it is more than likely that there are faults in the pipework, either in material or in design. Such systems should be tested and proved against the usual troubles of frost and overflowing.

If the water is from a well on the site, or nearby, its distance from any possible contamination must be viewed. There is always a risk in country places, where company's services are not available, of contamination of well water from either septic tank drainage or liquor from farm buildings, etc.

If the property is to be enlarged or the internal plumbing increased, be quite sure that the diameter of the supply pipe and the pressure are sufficient to convey the necessary increase in consumption. Try to trace any evidence of shortage in times of previous drought.

Electrical Supply

In the case of electrical supply from a public authority, the following information will be required :—

(1) The capacity of the supply (amperes).
(2) Voltage.
(3) Cycles.

The standard electric supply for normal use is 230 volts at 50 cycles, and the largest proportion of domestic appliances is wound to this standard.

It is both difficult and inconvenient to be forced to install equipment which does not work on this voltage ; should your client have the intention of using electricity for heating, power, cooking, and lighting, he will not thank you if you have failed to warn him of the fact that some museum piece of electrical supply is the only one available. Even in London there are a few streets, the houses in which have supplies at 100 volts, and the whole of the equipment used there would be useless were the tenants forced to change their residence to any other part of London.

If an electric supply is already laid on, it must be tested for leakage and insulation properties before any supply is permitted. Old wiring systems exist which do not comply with modern regulations, and if in bad condition or subject to overloading there is a grave danger of fire and of accidents. A registered electrical contractor should be consulted on these matters, and a report made out.

Gas Service

In the case of gas services, the question of diameter of supply pipe and of pressure is of importance, also the thermal standard of the gas.

It does sometimes occur that a gas main is inadequate for the consumption along the services, and those unfortunate owners of properties at the extremities of the service find there is no pressure of gas just at the time when the need is greatest.

Telephone

The telephone can now be installed in most parts of the country without much delay, and at standard rates. In isolated parts of the country, under present conditions the Post Office charge for installation is greatly increased—to what would prove, in some cases, prohibitive. If the property to be reported on is very isolated, it would be wise to make inquiries from the local postal authorities.

Wireless reception is to-day very important to some people, and inquiries and tests should be made as to the likely quality of reception in the district. The causes and possible cures of interruption and bad reception are described in Post Office pamphlets, and an investigation into such matters should not be overlooked.

Drainage

The last two items in this section of the "vetting" schedule are those of soil drainage, and land and storm-water drainage. If the drainage system is connected to the district sewer, trace the run of the drains; if no drain plan is available, make a rough sketch, show all gullies (noting what wastes each receives), down pipes, vents, and chambers. Note if there are separate systems for rain-water and soil, and note how each discharges. Note any gullies connected to the system which have fallen out of use. In such cases the absence of any flow of water to the gully will have caused the trap to dry up, and there will be a direct flow of foul gases through the gully to the property. Any runs under the buildings should be in iron, and in all cases the drains should be completely encased in concrete. All should be reliable, and of such diameter as to be self-cleansing. Note that a small pipe keeps cleaner than a large pipe with the same flow.

The by-laws do not permit of the discharge of wastes into rain-water heads, and downpipes from lavatory basins, etc., may be required to discharge at the ground surface over an open length of glazed channel with proper kerb. Note position and runs of vent pipes, whether quite clear of open windows, and in the right position for adequate ventilation of the system, i.e. at the high end of the drain. Old-fashioned grease traps should be replaced by deep-seal gullies, and an oil interceptor gully should be provided in the car wash.

In the case of buildings of more than two floors, the anti-siphonage system should be proved in good working order.

Inspect cess-pools and septic tanks; note construction, capacity, and condition, bearing in mind the possibility of your client wishing to install

SCHEDULE FOR USE IN "V

ITEMS (General)	REMARKS
Sale or Lease	
Agent. Solicitor. Owner.	
Note on terms of Conveyance	
Mortgagee. Building Society	
Who Pays:-	
Road Charges	
Ground rent	
External Repairs	
Which boundary fences are conveyed with property and which belong to adjoining owner:-	
Note on Easements and Restricting Covenants.	
Remarks.	

Location	Size	Number and Types of Windows	Fireplace & Mantle etc.	Wall Finish	Any Curtain Rails	Floor Finish	Lighting Natural	No. of Opening Lights	Best Size for Carpet or Lino	Power and Light Points	Fittings or Cupboards
GROUND FLOOR											
Dining Room											
Lounge											
3rd Room											
Kitchen											
Pantry or Larder											
Back Kitchen or Scullery											
Any other Room											
Garage											
Outbuildings											
UPSTAIRS											
Main Bedroom											
2nd do											
3rd do											
4th do											
Dressing Room											
Bathroom											
Lavatory											
Any other Room											

ITEMS (External)
Remarks on:- Roads Footpaths Approaches
? Space for Garage
Shopping Facilities:-
Transport:-
Aspect of Main Rooms.
External Wall Construction and Finish
Roofing
Describe Windows, steel? wood? etc.
Level of Damp Course relative to (i) Floors (ii) Garden (iii) Paving
Note Ventilators under floors
Flower beds and Wall Shrubs
Drainage:- Company's or Cesspool
" Outfall
" Ventilation Points
" Manholes etc.
General note on condition of garden and dimensions
DILAPIDATIONS:
List briefly structural and decorative faults which must receive attention before occupation

ITEM	Size	Number and Type of Windows	Number of Doors
Entrance Hall			
Landing			

VETTING" A SMALL HOUSE

REMARKS	ITEMS (Internally)	REMARKS
	Planning. Workability Accommodation	
	Changes of floor level	
	Any awkward doors etc.	
	Test soundness of wood floors	
	Test for dampness and for rot behind skirtings	
	SERVICES INTERNALLY	
	Electricity-Voltage, rates etc.	
	Hot and cold services:- Means of heating (1) Summer water. (2) Winter	
	Test and describe Cooking Apparatus	
	Sanitary fittings:- Number and position W.C's, Bath, Sink, Wash basins, Outside taps etc.	
	Examine Plumbing System:- design, traps ventilation size of wastes etc.	
	Bell system	
	Generally:- Landlord and/or Tenants fixtures and fittings to be taken over	
	Further Notes	

Floor Construction and Finish	STAIRCASE			
	Width	No. of Flights	Construction and Finish	No. of Risers (Winders?)

Job reference

more bathrooms, sinks, or wash basins, and the possible effect on the working of the existing installation. Such tanks should be at least 50 ft. from the nearest habitable building, the farther the better.

If the water supply is obtained within or near the site, when the drainage is by septic tank or cess-pool, a very thorough investigation must be made into the possibility of contamination.

The drainage system is a part of the property for which no guarantee can be given. You should bear in mind the possible extension of the system, and its effect on the working, and every precaution and test must be made to locate defects. If any doubt remains, it would be wise to advise that a firm of specialists be called in.

Amenities

Items under (4). A carefully worded paragraph of the report should be devoted to the description of the amenities and environment of the building, in order to convey to the lay mind some standard of selection to which the property aspires. Do not write up a house agent's report, which usually has the effect of condemning a property by the fact that one knows from experience properties so described do not exist in reality.

Such description should include some hint as to the natural characteristics of the property, and the possibilities of exploiting its natural features.

Shopping, Sports, etc.

The local facilities for shopping, for transport by road and rail, and for sport must be reported. Shopping should be far enough away to give residential seclusion, but at the same time be handy. Facilities for transport by road or to railway station must be considered, and in the case where your client is to travel to and from business by rail, he must not be misled on the question of ease of transport to and from the office.

In the case of sports such as hunting and fishing, find out the hunting districts and the meet centres, and what class of hunting and fishing country is within easy reach.

In dealing with the subject of amenities of any property it is as well to study previously the habits and sporting interests of your client, and to investigate those sports for which you know he will have an interest.

The Building Externally—Old and New Work

Items under (5). If you are "vetting" a large country property which is old, or even historic, one's first description under this heading should deal with the periods of construction. Look for the changes in facing materials, and the class of workmanship in each. The stone, brick, and joinery details and mouldings will almost certainly be different

if the property has been added to from time to time. It may occur that the buildings have a stone foundation up to plinth in one wing, and that the superstructure over this is of a much later date, using the old foundations, and rebuilding possibly after a fire.

If the building is brick or stone, follow through the courses and try to locate any straight joints or vertical joints in the facings which suggest that a wing has been added and a bond has been cut into the existing walls.

In such a case, no doubt any suggestion will be confirmed by a change in the style of window or door dressings. Even when an attempt has been made to keep the same character at the time the extensions were carried out, it is almost inevitable that, to the careful observer, some evidence of the difference in the old and the new work can be found which is conclusive.

Architecture

Having satisfied oneself on the date or dates of construction, a brief description of the architectural merits and demerits of the property must follow. Describe its character, grouping, period or periods, tone and setting. Be sure that the character of the buildings is more than skin deep—if half-timbered elevations and gables, are they just deal boards nailed on to brick and stucco backing? or are the elevations of rather recent brickwork with camber arches and sash windows? and has such work been carried out by a fairly recent owner as a cheap way of covering up some dilapidated half-timber building which was in need of more careful restoration?

Orientation

Note the orientation of the property, and make sure that there are sun, light, and air in the most important rooms. Report on obstructing outbuildings, and on overgrown trees which are likely to fall on the buildings, or which obstruct sunlight or undermine foundations.

If Additions or Alterations Are Contemplated

Should your client contemplate additions or alterations to any large extent, find out how the ground and floor levels will work, and what is the likely extent of demolition and clearing. Look for evidence of old foundations, excavations, disused wells or cellars. It often occurs that some such previous work is unearthed when an extension is begun, involving heavy expense not originally contemplated, and which might have been brought to light at the beginning had a more careful investigation been made. It was normal practice some years ago for all rain-water to be drained to a pit close to the domestic quarters, and from which the water was raised by suction pump.

If it is suspected that such a system exists, locate the pit and the

SCHEDULE FOR USE IN "VETTING" A LARGE HOUSE

It will be found that the best use of this schedule will be as a reference sheet to notes in a separate note-book. Proceed with your "vetting" survey item for item, in the order given, ticking off each as the required note or remarks are jotted down in the note-book.

Amenities and environment of house generally.
Roads, lanes, footpaths, bridges, and approaches generally.
Shopping facilities (distance).
Transport.
Sports (country and otherwise).
Water supply: source, analysis, query pressure adequate.
Storage tanks: capacity and head.
Electric supply: capacity (amps.), voltage, cycles. Query test necessary.
Gas: diameter of supply; pressure. Old or new installation?
Telephone facilities.
Inquire re wireless reception locally.
Drainage: septic, cess-pool, or main? Inspect; test out falls, ventilation.
Outbuildings, farm buildings, garage, etc., each separately.

The Buildings Externally

Period or periods of construction.
Architecturally and constructionally.
State of preservation.
Possible repairs necessary. (This item should be taken under trades as for a bill of quantities.)
Orientation, sun, light, air.
Obstructions, buildings, or trees.
Possible additions.

The Buildings Structurally

Defects in walls, buttresses, ties. Evidence of cracks due to settlement or overloading.
Spread and depth of footings and nature of subsoil.
Examine brickwork, joints, bond, and/or stonework. Facings. Cavity or solid work.
If rendered, test for hollowness.
Note on wall creepers and effect on walls.
Note reveals, cills, heads, and joinery externally.
Damp-course: type, condition, effectiveness, level, etc.
Ventilation under floors from outside.
Examine external plumbing.
Roof coverings: any sagging; inspect flashings and all intersections.
While on roof check over lanterns, skylights, dormers, gutters, parapets, cornices, flats, porches, hoods, etc.
General condition of external ironwork.
Repeat as far as applies—inspection of outbuildings, farm buildings, garages, etc.

Garden

Maturity, type of trees, plants, layout.
Paths and pavings (surfaces of), condition, drainage of; levels, steps, terraces, etc.

Internally

Note on planning and distribution of rooms generally, size, loftiness, lighting.
Each room separately: size, lighting (natural), height, aspect, position of fireplace, doors, etc.
Staircase construction and landings.
Bathroom and lavatory accommodation: adequate?
Cupboards.
Internal wall thickness: sound-proof test.
Floor finishings and state of repair.
Borrowed lights and fanlights.
Soundness of wood-joist floors.
Examine roof space: condition of timbers and under side of roof covering, beam filling. (While here note plumbing, electric lighting, and other services in roof void.)
Woodwork: dry rot in structural timbers? Quality of joinery.

Services Internally

Examine each in turn: hot and cold system, heating, grates, hearths,

SCHEDULE FOR USE IN "VETTING" A LARGE HOUSE—*continued*

mantelpieces, cookers; note types and construction. Heating apparatus.

Sanitary fittings and plumbing; ventilation of same and standard of material and workmanship generally.

Electricity: examine distribution and fuse board. Note metering and type of fittings.

Bells: try out system and schedule points.

Lifts: examine, note type, maker, and test out.

Internal decorative repair: finish on walls, quality of plaster work, etc.

DILAPIDATIONS

List and describe carefully (structural and decorative separately). Refer to terms of conveyance or lease.

Fixtures and fittings: note removable ones, landlord's and tenant's, note any reference to same in lease.

inlets. Plot the position on the plans and avoid breaking into it when excavating for possible extensions to either buildings, the drainage system, or services.

The Property Structurally: Investigating Walls—Items under (6)

See that all external walling is plumb; if a plumb-line shows defects, trace the reason. Is it a matter of settlement on foundations, or a pressure from inside? Bulging of walls under the wall plate indicates failure of roof timbers or shortage of ties and collars in roof construction, or maybe the result of too long a length of wall without bonding to cross-walls. This often occurs in rubble stone walling, when internal walls are frequently made of lath and plaster or thin brick. Make a note of any previous attempt at providing support by iron ties or otherwise, and investigate, when making an examination of the interior, the purpose served. Look closely for evidence of settlement—old or recent—shown by cracks in walls or in heads and cills of doors or window openings. The base of chimney stacks is a frequent place of settlement, also brickwork to bay windows. If necessary have a trial excavation made, and examine spread and depth of footings, and nature of the ground.

In clay soils a settlement may be caused by shrinkage or swelling in dry or wet weather, which in one season cracks and recedes from the foundations, and in another offers greater resistance to the foundation loads. Note if walls are built solid or with cavities, and whether in lime or cement mortar. In the case of stonework, see that the jointing is in good repair, and that no badly weathered stones exist in many places. Add a remark to the effect if you consider repairs to either stonework or brickwork would prove too costly. Inspect any renderings or stucco, sound for hollowness, or bulging or cracking. Has such work been done after the buildings have been completed, and for the reason that dampness was prevalent? Try to find what is the

structural material behind the facing, particularly on the faces which are exposed to the weather.

Damage Done by Creepers

When there is a heavy growth of ivy or other creepers, one can conclude with practical certainty that the wall structure has suffered thereby, and that stripping would disclose the need of external repair. The damage done by such creepers is first to destroy the jointing in the brickwork or other facing, and secondly to bulge the foundations by the ever-increasing diameter of the roots and base of the plant. An ivy root is capable of moving a well-bonded 18-in. brick wall a matter of inches over a period of years in the normal process of growth.

Until all such growth has been stripped it is impossible to make a full examination or to assess the extent of repair required.

Slate or Tile Hangings

If slate or tile hangings are present, examine the fixings and the conditions of the battening and counterbattening ; if felt has been used, see that it is in good condition and not falling away. Look for lead flashings to cills and vertical sides of all openings. If the hangings are carried round angles of buildings, see that the construction is sound at the mitres, and that a damp-course and flashing exist at the change from hanging to solid walling.

Wood Frames

Wood frames to windows and doors, if set in reveals, should be well pointed, and note if the cills are of hardwood and in good repair. Make a note of any failure in relieving arches or in lintels, or rot in the foot of door frames set externally.

Floors

Examine any cantilevered floor joists forming balconies, or supporting an upper wall in advance of the bearing wall under. In the case of half-timbered work the beams and posts should be examined, and a rough estimate made of the weight and stresses involved in the construction, and the state of the timbers to carry such. Before leaving external walls a check on thickness must be made in addition to construction. Your client may contemplate the addition of another storey, and you should have examined the walls to see if such extensions can safely be carried on to the existing walls and foundations.

Do Proper Damp-courses Exist ?

The existence of proper damp-courses must be proved, not only to external walls, but also to all internal walls and party walls. No horizontal damp-course should be at a higher level than the bottom of

the plate carrying the ground-floor joists, and should be not less than 7 in. above the ground at any point. If it is impossible to keep the ground level to the minimum of 7 in. below the damp-course, a slate or other type of vertical damp-course or properly designed dry area is essential. External walls to basements, against which earth rests, naturally require similar treatment, and, in addition, a horizontal course below floor level. In old properties, particularly when constructed with stone plinths, the absence of a damp-course is more than likely. Examine carefully, and if you are sure that none exists, and the property shows every sign of being quite dry, it is likely that owing to the porosity of the ground or the old practice of filling in clean dry rubble around the walls, and land draining, the walls are not damp. In such cases your client should be strongly advised to do away with any form of flower beds against the walls, and to discourage the planting of creepers or shrubs.

A Good Test for Dampness

A good way to test for dampness is to remove a length of skirting fixed to the suspected wall, and examine the back for any sign of rot. The same inspection should be made in rooms on the upper floors, particularly if creepers are growing on the wall outside, or if there are any defective down pipes near.

One of the most effective preventives of dampness in a building where no damp-course exists, is adequate ventilation under the floors. This has the further advantage of avoiding rot in timber floors and floor joists.

Defective external plumbing is a frequent cause of damp buildings. On careful examination, a bad joint in a down pipe will be shown by a tell-tale mark on the wall to which it is fixed. On brickwork such evidence is often found in the form of a fine green moss on the bricks and joints.

Such faults must be listed and dealt with on the repair or dilapidation schedule.

When Inspecting Roof Covering

The next, in order of importance, is the roof covering, and while this is being inspected, one should include the careful examination of chimneys and pointing, roof flashings, secret gutters to valleys, skylights, lantern lights, dormers, eaves gutters, cornices, parapets, and flats over porches, hoods, etc.

Look out for broken or loose slates or tiles, particularly at the verges, and the pointing at such places.

Leadwork

Leadwork, after some years, crystallises, and when bent up or disturbed cannot be redressed, and if defective will have to be replaced.

Chimney stacks should have damp-courses immediately above their intersection with the roof covering. Note any patching up in cement and sand as a temporary job to cure a leaking flashing. Such work is undoubtedly unsatisfactory, and serves only to make the problem of finding roof leaks more difficult.

Remember that there is a minimum roof pitch of almost all roofing materials, and be sure that in the case under examination it is adequate. Carefully go over the gutters, rolls, drips, gutter boarding, cess-pools, and outlets ; roof slopes for loose or broken tiles or slates ; ridges, hips, and valleys ; any sagging of the roof surfaces indicates failure of roof timbers, and calls for later investigation from the inside of the roof.

Make a note of any considerable quantity of green moss, as this should be removed. All exposed woodwork, such as turrets, barge boards, skylights, flagstaffs, etc., should be closely examined, and notes made of defective material, and of the general condition of such timbers.

Ascertain condition of barge boards, brackets, and exposed ends of purlins, eaves boards, fascia boards, and soffit boarding. Give detailed consideration of flats, search for sagging of the underboarding or joists, or any sign of failure.

On asphalte flats see that there are no cracks or blisters, and that the skirting is well keyed to the wall on the vertical and that, in the case of parapets, the turn-in is adequate.

The same strict examination of any of the patent roof coverings should be made in the same way, and noted.

Valley gutters, parapet gutters, box gutters, cess-pools, etc., are generally difficult of access, and it is essential that their condition be perfect.

Odd repairs and numerous patchings up of the roof work is evidence of a generally unsatisfactory roof over a period of years. Do not fail to notice such repairs, and to find cause and effect.

Levels and Falls

A thorough inspection of the roof and walls will have given you a good idea of the distribution of the buildings, and the run of rain-water gutters and down pipes. Now take a careful view round the buildings, examining together :—

(1) The relative levels of floors to adjacent ground and damp-course.

(2) The distribution of air bricks under floors and damp-course.

(3) The falls of the paths, terraces, or pavings, and the runs of surface water over these parts.

See that channels and falls on pavings, etc., are adequate (should not be less than 3 in. in 10 ft.) and away from buildings.

In the case of shrubs and flower beds against the walls, advocate their removal or recommend some practical form of protection to the external face of the walls.

External Metalwork

Wrought-iron work and external metalwork generally must be examined. In the case of balconies, the failure of a railing is a serious matter. The greatest corrosion usually takes place immediately above the stone or concrete to which the rails are dowelled. Satisfy yourself as to the extent of corrosion and the fixing generally.

Glazing

Examine the window glazing, if sheet or plate glass is fixed, and if the former whether of adequate weight and quality; if the latter, in sash windows see that the balance is adjusted for the extra weight.

Repairs Required

Make a general note for reporting on the state of external repair.

The terms of the lease or tenancy will tell you on whom the cost of repairs is to fall, and the responsibility for dilapidations generally. If these two items prove excessively high, a particular point must be made in your report to that effect, giving examples to illustrate and substantiate it.

If demolition of certain buildings is contemplated in the new scheme, make a list of the material likely to be available for re-use. Your client may prefer to re-use the old material in order to match up the new work with the old.

Internally (7)

Commence your detailed examination of the interior with the following points :—

(*a*) Are all rooms properly planned in relation one to the other, well designed, of reasonable shape and size, and well ventilated and lit ? In the reception rooms, are the fireplaces in a suitable position in relation to doors and windows, and how are they planned from the point of view of the housekeeper ?

(*b*) In the bedrooms, is there suitable wall space for beds and furniture generally ? Is the area of window adequate for the floor area, and are there sufficient opening lights ?

(*c*) Are the main and secondary staircases well placed, and of easy go ? Can one easily get out and away in case of fire ? Are landings spacious and well lit and ventilated ?

(*d*) Is the number of bathrooms, lavatories, and w.c.s adequate, including provision for domestic staff ?

(*e*) Inspect the cupboards. Are they of good size and well fitted ? Is there a good linen cupboard and airing cupboard, well placed away from outside walls ? What of the built-in cupboards in bedrooms, and, in the

	LOCATION	*Frontage on Street. Frontage Length*	*Floor Area and Height*	*Main Entrance*	*Exits to*	*Lighting (natural)*	*Services*	*Means of Access to Basement or other Storage Accommodation*
GROUND FLOOR	Entrance No. 1							
	,, ,, 2							
	,, ,, 3							
	,, ,, 4							
	,, ,, 5							
	Shop No. 1							
	,, ,, 2							
	,, ,, 3							
	,, ,, 4							
	Office No. 1							
	,, ,, 2							
	,, ,, 3							
	,, ,, 4							
	,, ,, 5							
First Floor	Office No. 1							
	,, ,, 2							
	,, ,, 3							
	,, ,, 4							
	,, ,, 5							
	,, ,, 6							
Other Floors	Office No. 1							
	,, ,, 2							
	,, ,, 3							
	,, ,, 4							
	,, ,, 5							
	,, ,, 6							
	,, ,, 7							
	,, ,, 8							

Corridors and/or Public Spaces	
Staircases (Main), Lifts	
Staircases (Escape)	
Areas	

VETTING " BUSINESS PREMISES

Note on Rateable Value	Lavatory and Cloaks Accommodation attached	Floor Construction and Finish	External and Party Walls	Landlord's and Tenant's Fixtures and Fittings	Window Area	Method of Heating	Remarks

kitchen and pantries, shelving, etc., which are so necessary in a house where large parties are held, and a number of servants is kept ?

(*f*) Are any important rooms divided one from the other by light partitions, where sound is conveyed too readily one to another ?

Make note of any awkward steps up or down from one room to another, and how such can be overcome. Note the aspect of each room, its view, and the relation of floor to ground outside.

Doors and Windows

On the upper floors inspect and make a note of any balconies or flats accessible from bedrooms, and be sure that the doors or French windows leading on to same are well designed, weatherproof, and easily opened and fastened.

Note floor finishings, and state of repair. Height of room if abnormal, and of windows, too. Are the latter easily curtained ? If the windows have internal shutters, see if they work or if they are merely ornamental. Generally, such shutters, which have fallen out of use for many years, provide dirt traps and harbour vermin.

Make a note of any borrowed lights or fanlights over doors, and find out for what reason they have been installed.

Sounding the Floors

Sound the floors by standing over the joist and jump and land heavily to trace movement. In old property it often occurs that the ends of floor joists have been built into bearing walls solid, and the lower edge of the bearing part of the joist has rotted away. This is the general explanation for unsteady floors in old buildings, and it is an expensive matter to renovate. Try to assess the degree of restoration required, if the floors are really bad, and report fully.

Examine Roof Space

Go up into the roof space and examine all trusses, rafters, purlins, hips, ridge pieces, ties, struts, plates, and ceiling joists, particularly the part immediately against the supporting walls, and all frame joists in trusses, etc.

Examine the skylights, and the lap of tiling or slating, and the method of fixing.

Always have a wary eye open for evidence of vermin or of birds and their nests in the roof space. While in the roof space, look out for any trough gutters running through it, and make sure they are in good condition, and free from debris. Such construction was the rule in Georgian times. Examine any brick or stone work to be seen from the roof space, and ascertain that the joists are strong enough for the storage of boxes.

Examine the extent to which beam-filling has been carried. To save

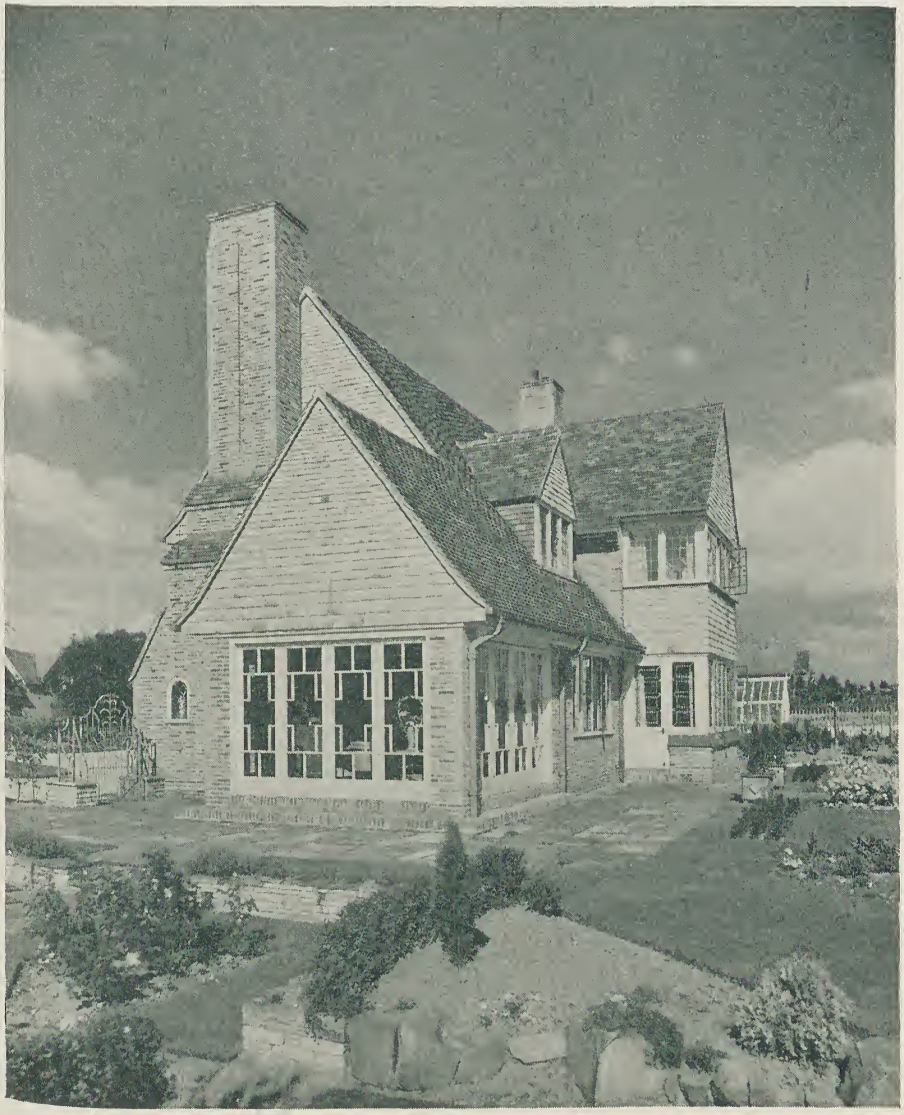


Fig. 1.—A GOOD EXAMPLE OF MODERN DOMESTIC ARCHITECTURE

House at Copt Heath, Warwickshire. Showing the sunny side of the house, occupied by the lounge. Opening off the lounge, through glazed sliding doors which disappear in the thickness of the walls, is the sun parlour (in the foreground). This forms an open-air extension of the lounge in summertime, as there are collapsible glazed doors on two sides. The dining-room is lighted by the large bay window. Hollow walls are used, faced with narrow multi-coloured bricks. (*Architect: Baron C. S. Underhill, F.R.I.B.A.*)

Fig. 2.—HOUSE AT COPT HEATH

Two more views. The circular feature forms the entrance and wall and window of the staircase.

a second visit to the roof, take particulars of cisterns, water pipes, overflows, electric wiring, and any other work requiring attention.

Woodwork

Carefully examine the joinery for quality both of material and of craftsmanship. At the same time you will be able to note the varying details of mouldings and of design generally, and this will be a very good guide to you in deciding when and what sections of the property were built, and added to or altered. Inspect the joinery internally, particularly dormers, fanlights, windows, doors, and porches. Panelling should be carefully inspected and sounded, and observed if such was designed for the position it now holds or whether it has been taken down from some other building and re-erected in the particular property you are "vetting." Any rare pieces of good period panelling in sound condition should be readily recognisable, and its genuineness or otherwise should be described in your report.

In the servants' quarters, look out for rotted floors and floor joists under or near sinks or wastes, etc. Do not let a floor pass without inspection because it is covered with lino or carpeted.

Are there Wormholes in Timber?

The presence of wormholes in timber calls for close investigation, so that some brief description of the habits and workings of beetles, etc., is opportune.

Common furniture beetles chiefly attack flooring and timbers of deal or pine, as well as furniture of harder woods. The "death-watch" beetle, however, is a far greater destroyer of structural timbers such as oak or chestnut, and when wormholes (or exit holes) exceed one-twelfth of an inch in diameter, it is fairly safe to assume that they have been made by this species. The damage caused by the larvæ of this beetle is incalculable, and there may be little evidence of its ravages till the sudden collapse of the timber occurs. It is therefore of the utmost importance, when "vetting" old roofs and timbers of all kinds, to ascertain how far any such trouble has gone.

When any suspicion of "death-watch" is aroused, plunge a knife into the timber, when the correctness of the diagnosis will result in a shower of powder composed of tiny pellets which are the excreta of the larvæ.

Services Internally—Grates, Hearths, Mantelpieces, Cookers, etc. (8)

Look over all grates, including fire-clay backs and cheeks, hearths, mantelpieces (tile or marble or cast-iron surround), and fixed fender kerbs. See that they are in good order and condition throughout, securely fixed, and that everything about them is suitable for its purpose.

When mantelpieces (or surrounds) are stained with smoke it is a

sign that the flues draw badly. If this defect is caused by the fire getting too little air, recommend that a length of 2-in. galvanised-iron pipe be brought from the outer air to a point as close to the grate as possible (in the tile surround), and there finish with a 6-in. by 3-in. brass hit-and-miss ventilating grid.

With fireplaces of the well or sink variety, or if it is intended to convert to this type, ascertain if the thickness of the back hearth below the actual fire is adequate, as there is danger from fire when an old hearth has been cut into. In some cases the floor joists are not correctly or adequately trimmed, and this can be checked by looking for positions of nailing of floorboards to joists. Sunken or cracked hearths suggest the need for examination of the trimmer arch, or of the trimmer or trimming joists.

Note the type and condition of the cooking apparatus, whether it be a kitchen range or an electric, gas, or oil cooker. Discover whether it is suitable for its work, well placed to the cook's convenience, and adequately lit by both natural and artificial light.

If a kitchen range, find out if there is a saddle boiler or a boot boiler behind the fire, and whether such boiler is responsible either alone or in company with an independent boiler for the domestic hot-water supply.

Hot- and Cold-water Services (8)

Schedule all hot services throughout the premises, including all draw-off hot-water towel rails or radiators from the same supply. Find whether the system is high- or low-pressure type, capacity and condition of the heating apparatus, whether independent boiler, range boiler, gas, electric, or a combined system.

Is the storage capacity of the cylinder sufficient, and is the cylinder well placed, and of copper or galvanised iron ?

Size and material of service pipes, their runs as far as possible, and whether there is a flow and return circuit to large draw-off points like bath and sinks.

Look for expansion pipe, safety valve, emptying cock, thermometers, and thermostats.

A suitable position should be found along the flow pipe where a length could be readily disconnected by a hot-water fitter in order that an examination of the interior of the pipe for furring can be made.

The following points should be checked in connection with the design of the system.

(1) The heating capacity of all radiators, coils, etc.

(2) Stop-valves to each or not.

(3) Heating capacity and fuel of the boiler, and maker's name.

(4) Have the system started up from cold and try all radiators and coils, to prove the circulation.

In installations of moderate size, where radiators and hot-water supplies are heated from a single boiler, see that the radiator heating is from the primary circulation, and the supplies from the secondary, the supplies being drawn from the outer cylinder, and the heating water from the inner cylinder or calorifier. This prevents rust from the radiators getting into the supply water, as there is no connection between the two services. Where oil fuel is used for the heating of the boiler, examine the apparatus generally, and find if the burner is efficient in working, silent, and in good repair. The oil storage should lie in an underground tank.

Cold Water (8)

The source of water and external work have been considered previously.

Internally commence by scheduling all draw-off services, and whether the supply pipe is adequate to deal with this number or any extensions contemplated.

Supply pipes to baths should be 1-in. diameter ; to sinks, $\frac{3}{4}$-in., and $\frac{1}{2}$-in. to water waste preventers and to geysers. A cold draw-off direct from company's main should be $\frac{1}{2}$-in. When outside w.c.s are subject to frost, it is preferable to take the supply to water waste preventers from the storage tank rather than direct from the main. At least one water-closet should be so served.

See that the storage tanks are clean and sound, properly covered, and protected from frost. Make sure that the ball cock is in order, and that there is a proper warning pipe for overflows.

See that the supports to tanks are adequate, and have a solid bearing on work fit to carry the weight.

Sanitary Fittings (8)

Schedule all baths, lavatories, sinks, w.c.s, urinals, and earth closets, see that they are all properly installed and up to modern standard. See that all traps, wastes, and overflows are adequate in size, and if of lead are undamaged and carry the full bore of the pipe. Look for puff-pipes where they would be required, and see that all fittings and groups of fittings are controlled by stop-cocks. Notice if water waste preventers are noisy or silent in action, particularly where they adjoin important rooms.

Note if drainage boards are properly designed, made of hardwood such as teak, and securely fixed.

The types of floorings in lavatories, w.c.s, bathrooms, pantries, sculleries, kitchens, etc., should be noted, and it is, of course, essential that the floor coverings in such cases should be impervious.

Be sure that all apartments containing sanitary fittings are adequately ventilated, also that larders are satisfactory in that respect, and are provided with fly screens.

Electric Service (8)

Recommend a full test, and examination of the electric lighting and heating installation by a registered wiring contractor, and see that he produces a competent report. This is most important, particularly if the installation shows evidence, by the design of fitting, of being old and out of date. If the supply is from a private plant on the property, there should be two reports—one dealing with the plant side of the main switch, and the other with the installation side.

Make a schedule of all electric light and heat points, fuse boards, etc., and assure yourself that the wiring and fittings are up to modern standards.

List all pendants, brackets, and skirting and wall plugs, with a note as to position of respective switches, and as to whether the latter are one-, two-, or three-way pattern. Note the wiring system, screw-conduit, slip-conduit, lead-covered, or rubber-insulated, and examine junction boxes and fusing system. Comment on the location of points and switches, and point out places you consider require additional points for such apparatus as vacuum cleaner, iron, refrigerator, etc.

Bells

Schedule the number of points served, and ascertain if any house telephones are run off the bell system ; similarly with burglar alarms, etc.

If wire bells are used, try out the system, and schedule the points as before, pointing out any deficiency of the system, or broken wires or bell hangings.

Lifts

Passenger or service lifts, whether electric, hydraulic, or balanced hand worked ; test the working. See that lift cages, gates, ropes, runners, and enclosures are in good order; that the speeds are satisfactory, and the running is smooth, silent, and free from vibration.

Internal Decorative Repair (9)

Assess the standard and quality of the decorations generally, and comment on them in your report. Schedule the kind and condition of decorations to ceilings, soffits, cornices, friezes, walls, dados, skirtings, doors, windows, floors, staircases, stair margins, mantelpieces, panelling, fittings, and other internal work.

Ascertain where surfaces are lined or hung with canvas, whether old wallpapers have been left under the pattern in use, and where papers have been varnished.

Keep an eye open for any valuable Chinese or hand-painted wall-papers, and notify your client of the existence of them, especially if hung on canvas and therefore easily removable.

Note surfaces finished in enamel, and note the structure behind—whether plaster, wall board, or suchlike linings.

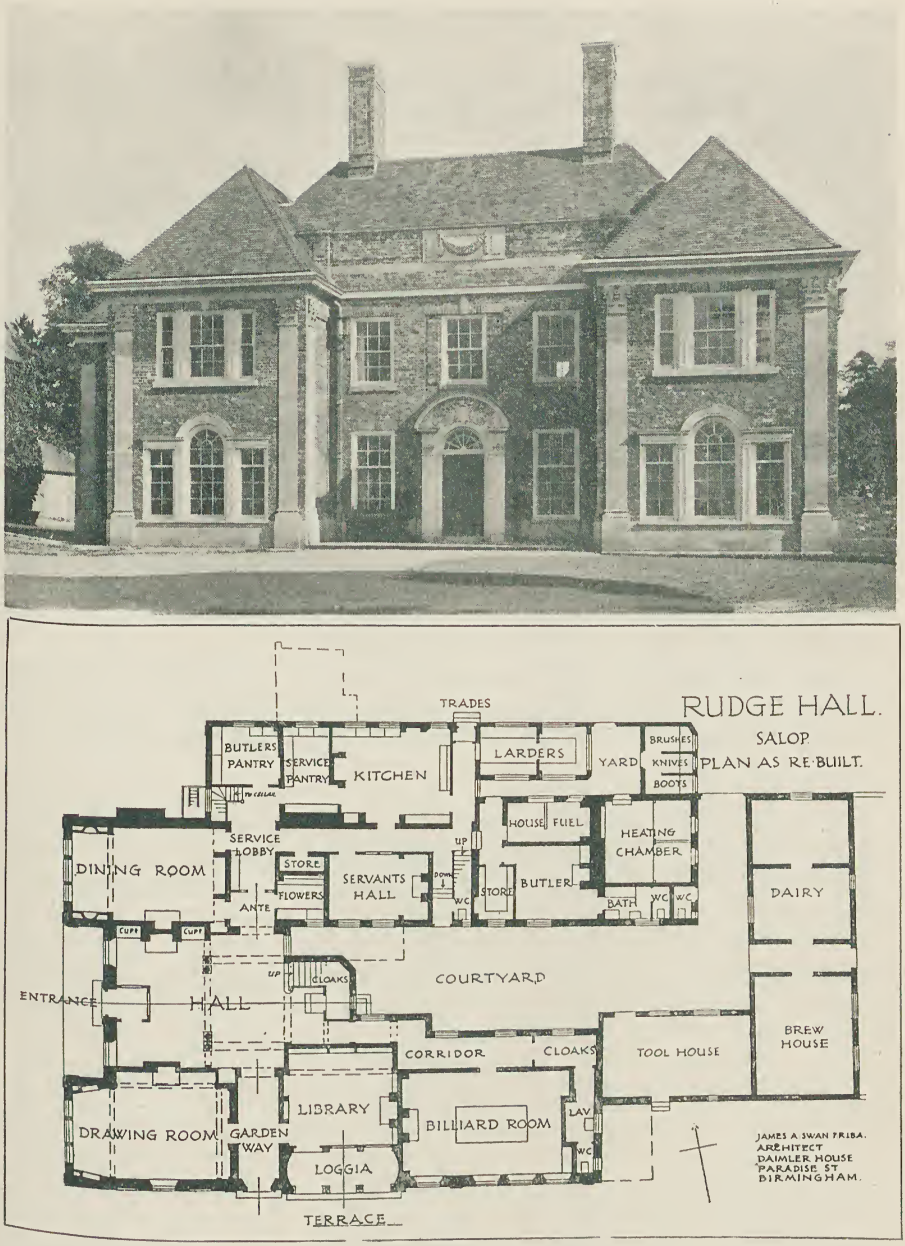


Fig. 3.—Correct "vetting"

Alterations in mid-Victorian times reduced Rudge Hall, Salop, to a commonplace cement-fronted structure with low and meagre slate roofs. The building has, as shown above, been converted into a more dignified building with raised west front and high-pitched tiled roofs. It was built and refaced entirely with old bricks on a stone plinth, with Corinthian pilasters and wide, overhanging cornice. (*Architect: James A. Swan, F.R.I.B.A.*)

Note surfaces varnished, stained, french-polished, or waxed, and condition. Make sure that all glazing and putties are sound, and note where plate or other special glass is used.

Special decoration, such as period work, leather work, tapestry hangings, etc., should be given special attention, and remember that beautiful old oak panelling is still to be found hidden away behind paint and plaster.

Note the condition of parquet and wood-block flooring.

If a maintenance clause is included in the agreement previously, see it has been complied with, and from your notes and schedule make a calculation of the required repairs if asked for.

Dilapidations (10)

Your notes and schedules will be a basis from which the list of dilapidations may be prepared. Trace from the conveyance or agreement on whom the responsibility is to fall. If you have been asked to assess the dilapidations, you will need to add quantities and measurements generally to your schedule and notes.

Landlord's and Tenant's Fixtures and Fittings (11)

It is sometimes difficult to decide exactly what constitute landlord's fittings, and those of tenant, and you will, most likely, have to use your own judgment, and refer to any agreement dealing with the subject.

Conclusion (12)

In concluding your report you will no doubt have to include some reference to the condition of outbuildings, boundaries, fences, walls, tennis lawns, roads, drives, paths, gardens, etc., according to the property being " vetted."

Each case must be dealt with on its own merits, and one's experience must be relied upon to allow nothing to be overlooked, and at the same time to avoid a too lengthy report by mentioning only the matters of note.

RECONSTRUCTED STONE

ARTIFICIAL stone, or " reconstructed " stone, as the makers prefer to call it, is one of the newer materials. Though it has been known for a considerable period, yet at one time it was little used except by the speculative builder, the architectural profession and the better-class builder often refusing to have anything to do with it, as its appearance, after a few years' service, was anything but pleasing.

Reconstructed stone has now, generally speaking, conquered the prejudices of the architect and the builder, and has established itself as a satisfactory and sound material.

The Composition of Reconstructed Stone

The basis is naturally concrete, a mixture of gravel and cement, in the proportions of 4 to 1, the gravel being screened from $\frac{1}{4}$-in. to $\frac{1}{2}$-in. gauge.

The facing on the above base is a mixture of crushed stone (or stone dust) and cement, the mixture being gauged at 3 to 1. The stone is received by the manufacturer as wastage from the quarries, or purchased already crushed as stone dust.

Method of Manufacture

The method of manufacturing a block of artificial stone is very similar to that followed in the making of a precast-concrete block. A box is made of the size required, and the facing is rammed in first to a thickness of $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in., and its ultimate density and texture assured. The backing is then rammed in, and naturally will firmly adhere or " key " to the facing. According to the colour or finish required, crushed Portland, Yorkshire, or whatever material may be suitable, is employed.

The next process is drying. The material is already so stiff that the blocks are taken into a drying-shed and the moulds removed. Here it remains 48 hours. During this period the temperature of the shed and the moisture of the atmosphere are controlled, the average temperature being about 68° F.

When taken out of the drying-shed, the blocks are placed in a covered shed for six to eight days, and then for a further six to eight days they must be protected from extremes of temperature. In this last case the floor is always kept wet, so that there will be a certain amount of moisture in the atmosphere. As a general rule it may be taken that no piece of reconstructed stone is ready for delivery until three weeks after manufacture.

It will be seen at once that with all moulded or decorative work a great deal—in fact everything, as far as appearance goes—depends upon the

Fig. 1.—USE OF RECONSTRUCTED STONE DRESSINGS
On extension of Turner School, Redcar, Middlesbrough. Entrance to Great Hall. (*Architects: Kitching & Co.*)

mould or case, and every workshop for artificial stone needs a carpenters' shop. At the same time, the use of the moulds again and again renders ornamental and decorative work a good deal more economical than the same carried out in natural material.

Artificial Stone Columns

Perhaps one of the most difficult objects to make is the column, owing to its taper, and the slight "entasis" or swell on the shaft. Anything of this character is cast on end, and is usually reinforced with one or more iron rods, which, besides reinforcing the stone, act as dowels.

In cases of this kind the material is usually vibrated. The opportunity of always being able to reinforce it with steel is one advantage of artificial stone over the natural material.

Probably the only limit to the size of a stone head or lintel is the difficulty of handling when the piece gets to be extraordinarily large, and, naturally, extreme care must be taken with regard to carriage and delivery, stacking, etc., as all arrises are liable to chip.

The foreman in charge of the work always receives a drawing showing the set out and quantity of blocks required. Each block is numbered according to the drawing, and the builder should receive a copy of this as a "fixing drawing," as each block must have its own place.

Occasionally a question may arise between the architect and the manufacturer. Take, for example, the column.

An architect may desire his column shaft to be in three "drums," showing the joints clearly marked. It is generally considered easier for the manufacturer to cast his column in one, especially if entasis is required, owing to its taper and entasis making it difficult for the three moulds to

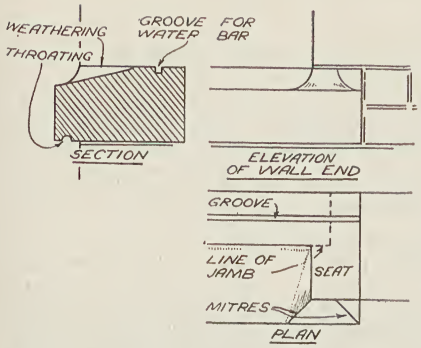
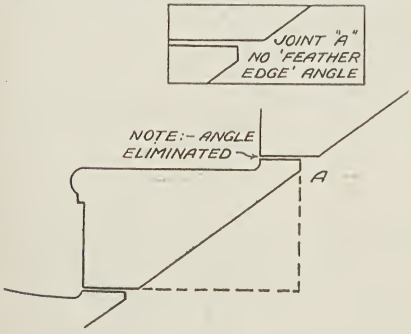
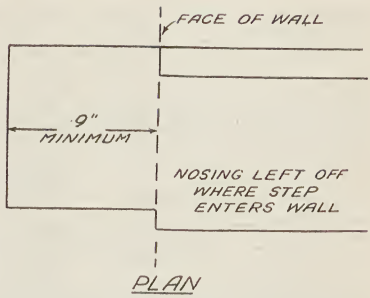


Fig. 2.—RECONSTRUCTED STONE CILL





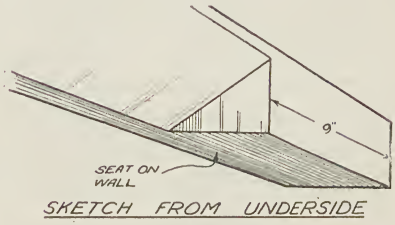


Fig. 4 (*above*).—A SQUARE SEAT SHOULD BE LEFT AT END OF SPANDREL STEP

Fig. 3 (*left*).—SPANDREL STEP MADE OF RECONSTRUCTED STONE

fit. So he suggests the column be cast in a single piece, and the two horizontal joints to be incised on it before the facing has begun to set, and then pointed in cement. Of course, the appearance is the same in each case, except for the possibility of the pointing falling out. This sort of thing may occur in any case where the architect or designer wishes his joints to be emphasised.

Where Reconstructed Stone Can Be Employed

Broadly speaking, reconstructed or artificial stone may be used as a substitute for natural stone in any case where the latter may have been employed. Heads, cills, arches, mullions, string courses, cornices, copings are all suitable for this material.

For Window Cills

The average window cill may be taken to show the economical use of this material. Fig. 2 shows the groove for water bar, the weathering of the upper surface, the throating on the under side, the seats for the jambs, and the mitring and returns of the weathering. With repeat work of this kind the amount of labour is very small compared to that which would be expended on the natural material.

Reconstructed Stone for Staircases

In staircase work, a very careful drawing must be made in the first place showing the staircase, with the number and size of the steps. If the height to be attained is 10 ft. from floor to floor with sixteen steps, the height of each is $7\frac{1}{2}$ in. But the joint must be allowed for, say $\frac{1}{4}$ in., and in this case the stone step itself will be $7\frac{1}{4}$ in. There may be a special or rounded step to start the stair. The top step may also differ slightly. The other fourteen, if in one flight, may be exactly alike.

Another useful point regarding reconstructed stone steps is that they can easily be made as spandrel steps (see Fig. 3). This looks better on the under side. Note the ingenious way in which the internal angle is disposed of at A, leaving no corner for dirt. One point must be stressed, viz. a square " seat " should be left at the end (Fig. 4), so that the steps bed properly on the wall. This seat should be at least 9 in. in the case of " hanging " steps, and $4\frac{1}{2}$ in. if there is a supporting wall at each side. Also, the moulded nosing must be stopped at the same point. All these stair treads in reconstructed stone can be made " non-slip " by means of a carborundum finish.

Cutting

Another good point about reconstructed stone is the ease of making mortices. Whereas in the natural material these have to be cut, even for a lewis bolt, with this material an iron ring for lifting hook can be let in the stone. In the case of a stone coping carrying an iron railing, with a correctly set-out drawing all mortices for the standards can be made at the time the coping is cast, whereas in a natural one all these would be cut separately. We do not mean to say that reconstructed stone cannot be morticed or cut, but it is certainly inadvisable to disturb the face. On the contrary, it is quite a simple matter to shorten any piece if by some error it is delivered too long.

Crazing

One of the great faults of reconstructed stone is its habit, after a short period of weathering, of " crazing." By " crazing " is meant that the surface becomes marked with a series of fine hair-lines, spoiling the appearance. It is, however, possible to obtain reconstructed stone guaranteed non-crazing.

Building Blocks

Besides the various special " dressings " already mentioned, ordinary building blocks are manufactured. Any type of joint can be made, either the plain butt, rebated, or chamfered. Also, the surface can be finished with a plain dressed face, vermiculated, or rock-faced, according to requirement.

Garden ornaments are fashioned out of this same material, such as vases for sun-dials, bird-baths, gnomes, etc.

FURTHER NOTES ON REINFORCED CONCRETE

FOR THE FOREMAN BUILDER

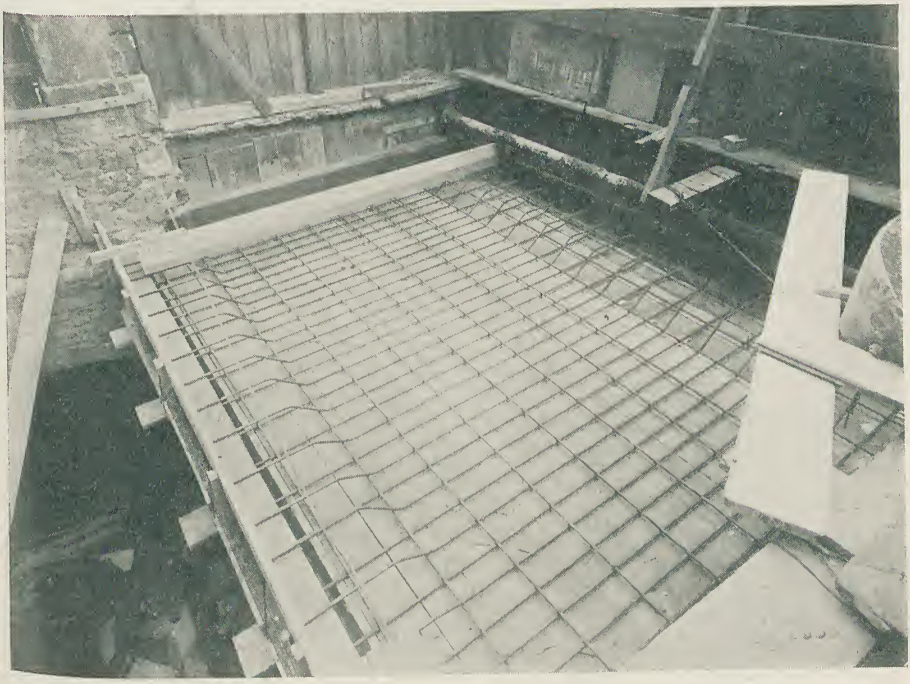


Fig. 1.—For reinforced-concrete forecourt over basement
Reinforcement bars in position ready for the concrete.

ALTHOUGH the design of reinforced-concrete buildings is the province of the architect, the application of the materials used in their construction is the province of the builder, and if he is to carry out his work intelligently he must have some knowledge of the principles underlying the combination of steel and concrete.

Concrete is normally used for its ability to resist compression, that is, crushing loads, and according to its quality and age will withstand up to 6,000 or 7,000 lb. per square inch. Though strong in compression, concrete is extremely weak in tension, such tensional strength as it has being readily destroyed by a sudden load. In addition, when setting, it

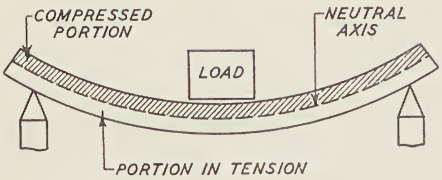


Fig. 2.—TIMBER BEAM UNDER LOAD

contracts, this leading to interpenetration by hair cracks which destroy the cohesion of its parts.

Reinforcement Used to Strengthen Concrete in Tension

A timber beam supported at its ends and loaded at the centre will bend, and if the timber be of a flexible character, and the load severe, will attain some such shape as shown in Fig. 2.

The upper surface of the beam, being on the inner and shorter side of the curve, is obviously shortened and compressed, whilst the lower side is similarly lengthened. Some portion near the centre of its depth is neither lengthened nor shortened, thus being neither in compression nor in tension.

This portion is usually considered to be a plane surface, and we can imagine the beam to be built up of a very large number of thin boards with the upper ones compressed along their length, the centre one unaltered, and the lower ones lengthened.

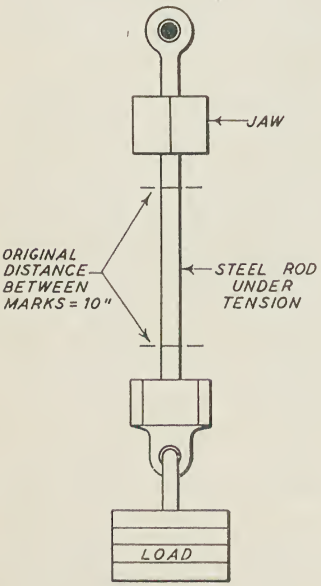


Fig. 3.—WHAT HAPPENS TO STEEL ROD UNDER TENSION

The rod will stretch, the amount being measurable by checking distance between two marks, as shown.

Were concrete used instead of timber for the construction of the beam, although the bending might not be apparent to the eye it would be measurable; the same conditions would obtain, and the lower parts would be in tension whilst the upper parts would be compressed.

Concrete being weak in tension, it is the object of reinforcement to strengthen the concrete where it is in tension, leaving it to care for the compression loads unaided. This, as we have seen, it is quite well able to do.

Why Steel Rods Are Used for Reinforcement

The basic fact which makes it possible to combine steel and concrete is that the latter contracts on setting in air. If a steel rod be embedded in a mass of wet concrete it will be found that considerable force is necessary to withdraw it when the concrete is set. If a steel plate be placed on wet concrete, however, although it will resist removal when the concrete is set, it can be knocked off by a sharp blow. In the first case the concrete grips the steel, whilst in the second it only

adheres. The grip depends upon the quality of the concrete ; upon whether it has been well or badly rammed around the rod ; upon the condition of the surface of the rod, as to whether it be rough or smooth. A polished rod is less gripped than one of commercial mild steel, with its rough and lightly rust-filmed surface, whilst an oily rod is lightly held.

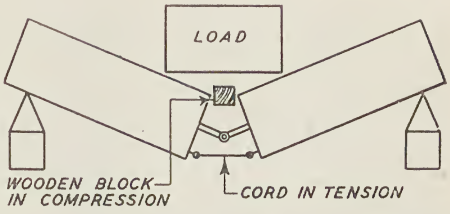


Fig. 4.—SHOWING PARTS OF BEAM UNDER TENSION AND COMPRESSION

From time to time specially shaped bars have been introduced carrying indentations, raised ribs, or projections of one kind or another, with the object of increasing the grip, but as the grip must depend upon the strength of the concrete these bars do not achieve their purpose if set near the soffits of beams with perhaps a bare inch of cover. The actual grip or, as it is usually called, adhesion of mild steel in concrete is around 250 lb. per square inch of surface, but added security is obtained by hooking the ends of the rods in a semicircle of about four rod diameters, or by splitting the ends of the rods for a few inches and opening into a fishtail.

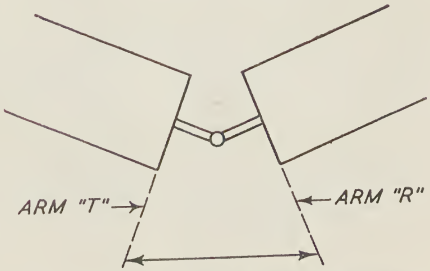


Fig. 5.—THE LOWER THE RODS THE STRONGER THE BEAM

Steel Rods Must Be Placed Low in Beam

We must now consider what happens to steel when it is called upon to bear a tensional load or pull. If a rod of, say, $\frac{1}{2}$ in. in diameter be gripped in a suitable jaw, as shown in Fig. 3, and the other end loaded with a gradually increasing weight, the steel will be found to stretch, this stretch being measurable by checking the distance between two marks scratched on the rod at, say, 10 in. apart.

If from time to time the load be removed it will be found that the rod will return to its original length, just as an elastic band stretched between the finger and thumb will return to its original shape when released. At some point in the loading, however, the rod loses its power to return, and the load in pounds per square inch section of the steel at this point is known as the elastic limit.

Up to this point, dividing the load in pounds per square inch by the amount of stretch per unit of length always gives a constant result. As an example, a bar 10 in. long stretched one-hundredth of an inch has a unit stretch of $\frac{1}{1000}$. If the load were 30,000 lb., the division of load by stretch would give 30,000,000, and if the load were half the stretch

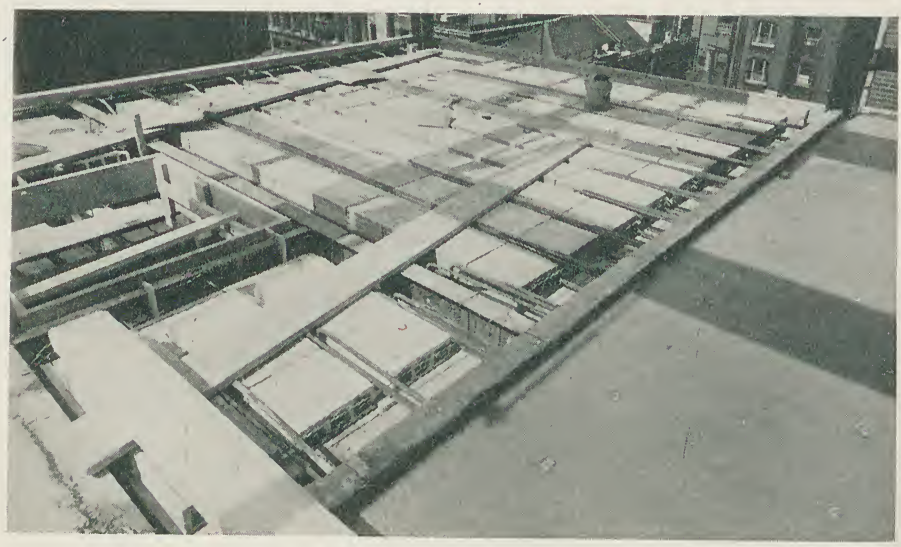


Fig. 6.—HOLLOW FLOOR CONSTRUCTION
Showing completed surface in foreground, with fixing clips for battens.

would be half, and the result of the division again 30,000,000. This figure is known as the coefficient of elasticity. With ordinary types of steel the elastic limit is reached at around 32,000 lb. per square inch, but such steel is never designed to carry more than 16,000.

Reverting to the timber beam, we can imagine it made up of two parts hinged at their centres, as in Fig. 4. The load will try to break the back of the beam at the joint, but we could prevent this by tying a cord across the gap or by jamming in a piece of wood in the position shown, when the cord would be in tension and the wood in compression.

In the enlarged view of the joint (Fig. 5) we can see that the farther down the arms R and T we fix the cord, the less pull it will have to withstand, until were the arms lengthened as shown by the dotted lines a heavy load could be sustained on the beam by a light pull.

This amounts to saying that the deeper the beam the stronger it is, or that the lower we place the steel rods the better they will be able to resist the tensional pull. Deep beams being uneconomical, as regards both material and space, the designer keeps them as shallow as possible, depending upon the correct placing of the steel by the builder.

Thickness of Covering for Reinforcement Rods

How low can the rods be placed with safety ? Although considered fireproof, concrete buildings usually contain inflammable things, and a layer of concrete must be provided as protection to the reinforcement. When steel is loaded it stretches, and if the concrete is not to spall from

the under side of beams there must be a certain thickness under the steel. In addition, concrete is permeable to damp, and uncovered or sparsely covered rods would corrode. Allowing for these three factors the usual cover in slabs is ½ in., and in beams 1 in.

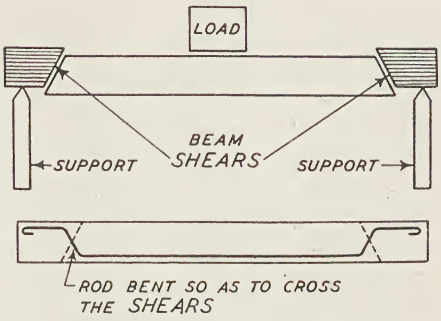


Fig. 7.—BEAM REINFORCEMENT TO RESIST SHEAR

Strengthening Beam to Resist Shear

A very usual type of beam reinforcement consists of several rods, of which perhaps two are bent up as shown in Fig. 7.

These are intended to strengthen the beam to resist what is known as shear, which is a tendency for a portion of the beam to be pushed bodily out of the main part, as shown by the shaded portions in Fig. 7.

A man walking on a scaffold board supported at both ends bends the board farther as he gets nearer the middle. This may be stated in the following terms : the bending moment increases as the distance of the load from a support. This being so, it will be seen that the greatest stress on the steel reinforcing rods comes around the centre of the span in a normally loaded beam, and it is here that most steel is needed. A close inspection of a plate-girder railway bridge will show that there are more plates at the centre than towards the abutments, this being done for reasons of economy. In a reinforced-concrete beam, then, we can afford to bend some of the steel rods after they have done their bit near the centre, and take them diagonally upwards to cross the parts of the beam which are subjected to shear, bending them back again parallel to the top of the beam so as to give a secure anchorage.

The designer calculates the position of the steel so that it can do this work to the best advantage, and it is the builder's job, knowing the reason, to see that the drawings are strictly adhered to both in the bending and in the placing of the bars.

Why Continuous Reinforcement Is Employed

In buildings of any size it frequently happens that slabs and beams are designed with steel running near the bottom, then turned up and running parallel with the upper surface and over into the next bay.

This form of reinforcement is called continuous, and the reason for its use is seen in Fig. 8, where the right-hand portion of the beam, being loaded, tends to raise the unloaded portion in the next bay.

To omit this steel on the plea that it is unnecessary is dangerous, to say the least of it, yet it is often done.

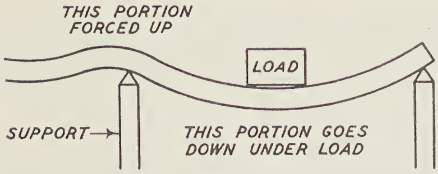


Fig. 8.—THE REASON FOR CONTINUOUS REINFORCEMENT

Reinforcing-steel

Reinforcing-steel usually consists of plain round rods, varying from $\frac{1}{4}$ in. in diameter upwards. They should be of steel, with a tensile strength of between 28 and 32 tons to the square inch, and be capable of being bent cold in a half-circle around a piece of their own diameter without showing signs of cracking at the bend. The rods should be clean and free from loose rust.

Storing Rods

The best method of storing rods is in racks, which can be readily made by driving in a row of strong posts at 5-ft. centres over a length slightly less than the longest rods to be used. Bolts or short lengths of rod can then be driven slantwise into the posts to form arms, thus allowing of the segregation of the various sizes. A light roof over all will protect the rods from direct rain.

Rod-bending Bench

The bending-bench should be alongside the rack, and should be as strongly constructed as possible of good baulk timbers placed about 3 ft. 6 in. from the ground, and parallel with the storage.

As in most reinforced work there is a multiplicity of similar shaped bends, a second storage rack on the other side of the bench is an advantage, as the bends can be hung as they are finished and not thrown on the ground, where they become tangled and rusty.

Bending the Rods

The actual bending can be done either by driving steel pins into the surface of the bench in accordance with a chalked diagram, and forcing the bars around the pins by the use of a length of steam barrel slipped over the rods, or by a bending machine. The latter is in every way preferable. The bends are smoother, more rapidly made, especially if the bender be let into the bench top, so that the bending groove is flush. Using a geared bender, bars up to $1\frac{3}{4}$-in. diameter can be readily handled.

A light roof over the bench will allow of work whatever the weather, and will also avoid damage to drawings and bar schedules.

Cutting Rods

Cutting is easiest done with a bolt-cropper, care being taken to see that there is a pair of spare cutters always ready for exchange, and that the cutters are at least one size too large for their job.

The use of the oxy-acetylene torch is sometimes advocated, though

the intermittent nature of the work makes for constant lighting and consequent waste of gas. Recently a good deal of bar-cutting has been done with an electric hand-saw using carborundum discs, and where current is available this is a rapid method, particularly with bars over $\frac{3}{4}$ in.

Assembling Sections of Reinforcement Rods on Bench

Many sections of reinforcement can be inserted in beams or columns after wiring up, and these can be assembled on the bending-bench. Cradle irons of the shape shown in Fig. 9, and driven into the bench, will be found of great assistance.

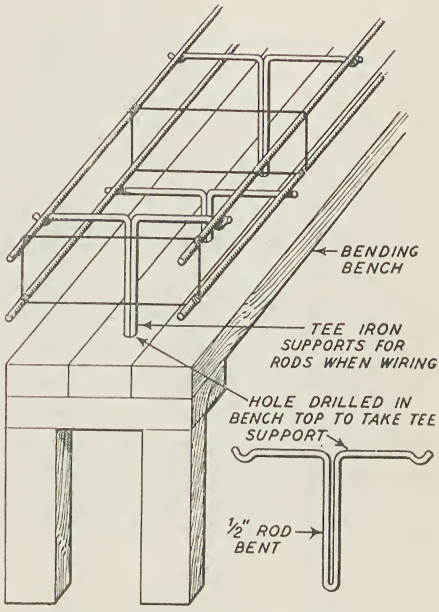


Fig. 9.—ASSEMBLING SECTION OF REINFORCEMENT ON BENCH

Cradle irons of shape shown and driven into bench will be found of great assistance.

Wiring of Joints

The wiring of the joints should be done securely, and it is unlikely that any reader will use the old method of supplying coils of soft-iron wire from which the ties are to be cut. Much of the wire is tangled and wasted, and the better method is to adopt either ready-cut lengths or one of the preformed ties sold by suppliers of concrete utilities. One such is adapted to be looped around the rods and twisted tight by a special tool, whilst another consists of springy wire clips of varying sizes to fit the rods. The former would seem to be preferable.

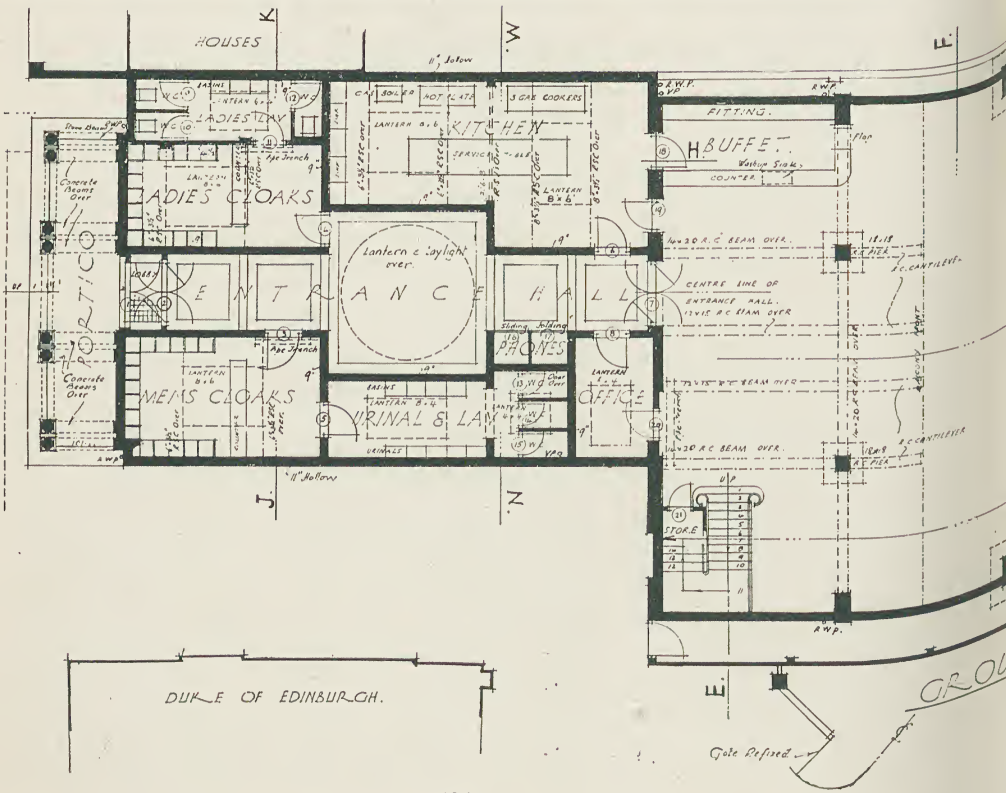
Placing the Rods

After the rods have been bent, the next step is to place them. The care taken in the drawing-office to ensure that the rods will fit in the forms renders placing easy if the bending has been carefully executed. If it has not, the bending should be most carefully checked, to avoid a constant repetition of the trouble right through the job.

Having brushed or washed the forms clear of odd bits of wood, sawdust, and rubbish they should be coated with mould oil or whitewash, the former being preferable. Mould oils, when bought cheaply, consist of refuse emulsified with water. The cheaper it is the more water you obtain for your money. Oils can now be bought which can be mixed on the site with the required bulk of water,

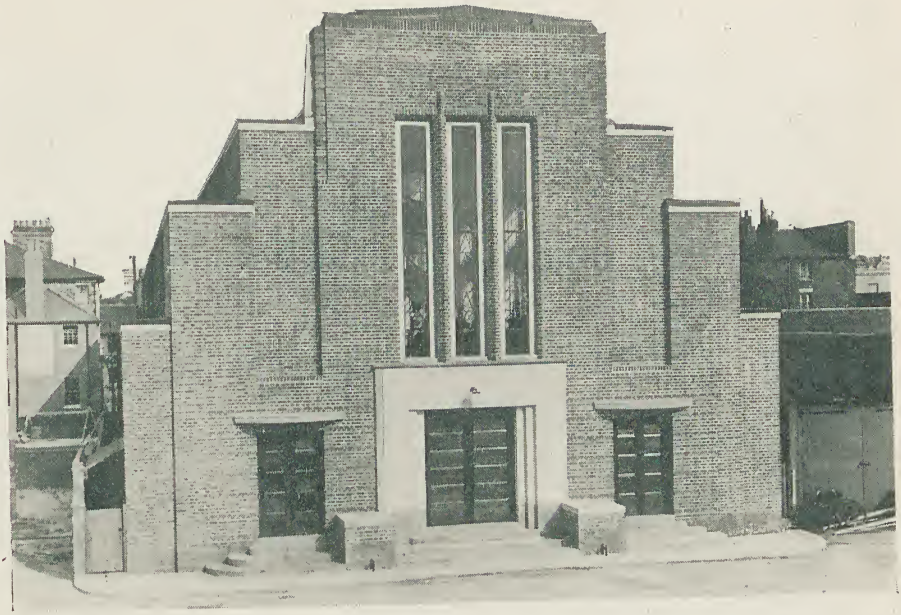
Fig. 1
Corn

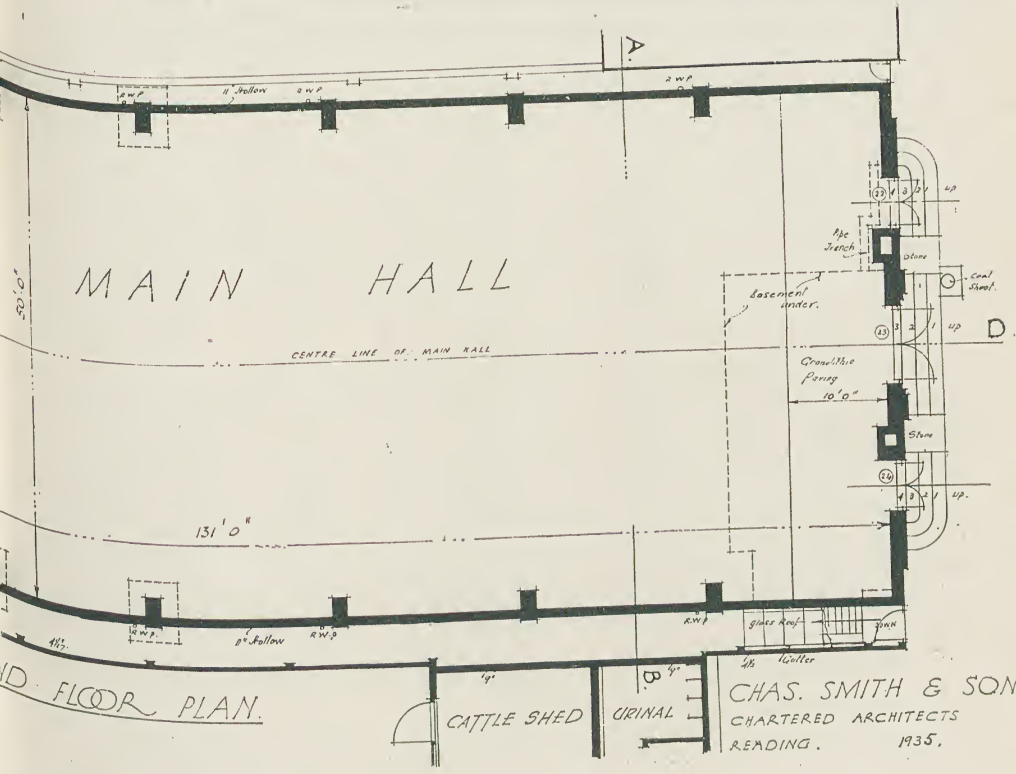
Show
ground-
cluding
details
given i
the nex
principa
shown o
open
Clipsha
stone
stone ea
pedimen
the righ
entra
the Co
(*Archi
Smith &*



READING
HANGE

below, the
plan, in-
main hall,
which are
g. 10A on
age. The
ntrance is
e left—an
rtico of
natural-
mns with
lature and
over. On
s the west
e from
Market.
s—*Chas.*
n.)





D FLOOR PLAN.

Fig. 10A.—INTERIOR OF MAIN HALL, 131 FT. LONG BY 50 FT. WIDE, READING CORN EXCHANGE

Note the six reinforced-concrete elliptically shaped arch ribs or trusses at 19-ft. centres. The radii of the soffit are about 19 ft. for the middle portion and 35 ft. 6 in. at the sides. The hall is roofed on each side with a series of concrete flat roofs which rise in tiers to the highest flat, which is 36 ft. above floor level and 17 ft. wide. These flats are carried by concrete beams between the trusses. The design of the roof allows for the provision of a large amount of lighting from vertical windows. The ribs are carried on footings 6 ft. by 5 ft. At the farther end of the hall will be seen the balcony, which is 44 ft. long and 12 ft. 6 in. wide and carried on concrete cantilever beams with an overhang of 8 ft. supported on two 18-in.-square concrete columns. The front of the balcony is of reinforced concrete and wrought-iron grilles. Further illustrations are shown on the previous pages. (*Architects: Chas. Smith & Son.*)

and with a guarantee of non-separation, the cost being around threepence per gallon.

Heavy reinforcements can be suspended by wire ties from cross-bars blocked up on the sides of the beam boxes, or rested on precast blocks of concrete which will amalgamate with the bulk. Wood blocks are not to be recommended. They show when the shuttering is removed, and are difficult to dislodge. A new form of wire bridge can now be purchased which can be placed under rods, but would seem likely to give rise to rust spots on the soffits.

VARIOUS TYPES OF REINFORCED MEMBERS

Stanchion and Column Bases and Footings

Stanchion bases, column bases, and footings are the most important and most frequently neglected portions of a building. Being in effect

reversed beams, with the stanchion forming the support and the earth pressure upwards a load about the ends, the tendency is for the concrete to break off in an upward direction, so that the steel must be placed in the bottom of the slab. The stresses being high the rods should be well hooked ; well wired together to prevent movement during filling ; and if for columns should be provided with dowel rods projecting at least twenty-four times the diameter of the rod, and securely braced in a vertical position whilst filling and setting are in progress.

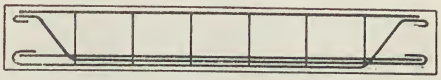


Fig. 11.—TYPICAL REINFORCEMENT FOR 6-FT.-SPAN LINTEL

It is well to remember that a column base may have to carry a load in the nature of a hundred tons, and such a load needs good workmanship.

Lintels

Lintels, although often relieved of much of their loads by the arching of brickwork above them, deserve as much care as any other part of a building, especially in those cases where beams run into the walls above them. It is not sufficient to lay two or three odd lengths of ½-in. bar in the bottom, and be satisfied that they are reinforced. Allowance should be made for shear, as explained in the section on beams, and the stirrups wired securely. The sketch (Fig. 11) shows a typical reinforcement for a 6-ft.-span lintel, with the cover of 1 in. clearly indicated.

When they can be precast time is saved by constructing a multiple mould, stop pieces being used to achieve the required length.

Columns

In constructing reinforced-concrete columns it is difficult to realise that concrete capable of carrying, say, 40 tons on a square foot should need steel to assist it, but the filling of the column boxes a few feet at a time results in a series of almost isolated blocks sitting one on the other. Steel rods act, therefore, as connecting dowels. There is another reason for the use of reinforcement where a somewhat slender column carries a beam which has been cast so as to be monolithic with the former. Loading of the beam produces a small but measurable deflection, and this in turn tends to bend the column, the upper portion bending outwards and the lower inwards.

To prevent buckling of the rods they are tied together by stirrups wired to them at intervals.

Where columns have to carry large loads it is frequently an advantage to have some part of the compression carried by the steel, each square inch of the latter replacing 15 sq. in. of concrete. In such cases six or

Fig. 12.—CAFÉ AND TEA TERRACE, NEW BRIGHTON BATHING POOL, EMBODYING THE USE OF REINFORCED-CONCRETE BALCONIES AND CANOPIES CANTILEVERED OUT FROM THE MAIN WALLS

Surfaces rendered in "Snowcrete," with continuous bands of permanent colour in black and green faience. (*Architect—L. St. G. Wilkinson, M.Inst.C.E., Borough Engineer, Wallasey.*)

eight bars are used, and great care must be taken with the binding and the ramming of the concrete. To assist the latter, inspection traps are left in the shuttering, so that the work can be inspected as it proceeds.

Precast Roof Trusses

The advantages of casting trusses on the ground are numerous, and this method is becoming popular but needs care if good results are to be obtained. The shuttering must be strong, accurate, and of sound timber, well oiled to prevent adhesion. Cross-braces should be used freely, and all arrises slightly rounded.

As there will be a multiplicity of similar trusses it is usual to arrange the mould so that after the casting of the first truss the former can be raised by the addition of further widths of board, thus allowing the casting of four or five trusses one on top of another, paper being placed between successive layers of concrete to prevent adhesion.

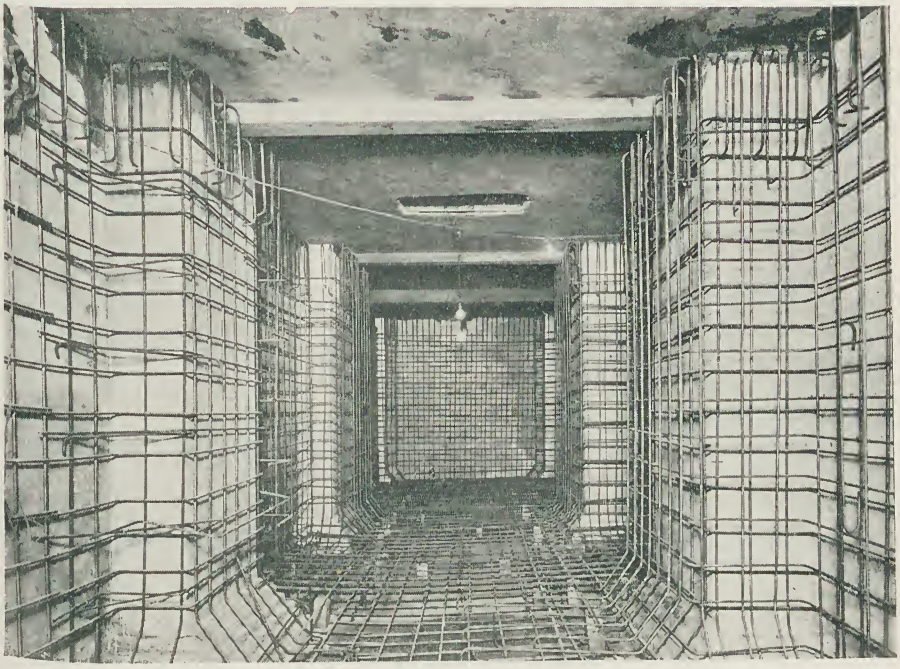


Fig. 13.—REINFORCED-CONCRETE TANK

Here we see the reinforcement of the inside concrete casing of a water tank 11 ft. deep, at City Gate House, Finsbury Square, London, the walls and bottom 9 in. thick throughout, reinforced with steel rods on both sides, with $\frac{5}{8}$-in. diameter rods at 9-in. centres. The mixture of concrete used was 1 part Portland cement, $1\frac{1}{2}$ part clean washed sand, and 3 parts washed ballast to pass $\frac{3}{4}$-in. mesh. (*Architects : Sir G. Gilbert Scott and F. R. Gould Wills, F.R.I.B.A.*)

Eagerness to see the trusses hoisted should not be allowed to prevent the longest possible time being given for hardening, and when the actual hoisting is done the slings should be placed so that the truss is lifted in the position it will occupy under load, a pair of stout deals being lashed alongside to prevent damage, and to strengthen it.

All necessary holes can be cast in the members by the insertion of tubular sleeves, which will also allow of the use of through bolts to stiffen the mould.

As in every other branch of building, experience is the best teacher, but with some slight idea of the principles underlying reinforcement there should be no excuse for such blunders as having several tons of reinforcement left over from a job, nor should it be possible to excavate a faulty concrete road and find the reinforcement under the concrete instead of in it.

Formwork is dealt with in another section, and it is unnecessary to

say anything further about it except that it cannot be too strong, for once concrete has bulged nothing short of superhuman efforts will get it back into position.

Placing of Concrete

The placing of concrete needs as much care as any other part of the work, particularly when the reinforcement is complex. It is good practice to commence filling with a more fluid mix than will be used in the bulk, but this is not to be taken as meaning that more water is to be added per batch. The same result can be achieved by a reduction in the amount of the aggregate, and the slight extra cost in cement per cubic yard of mix is well worth while, the exposed faces of the work being dense and of good appearance instead of requiring filling and patching.

Ramming should be done with thin tools, whatever be used. Blunt rammers tend to trap the larger particles and force them to the bottom of the form, where they are a hindrance to the flow of the mortar beneath the steel. The secret of good work is to fill in thin layers, not in heaps at one end, trusting to the mixture to flow lengthwise along the form. Another advantage of thin layers is that far less tamping is required.

Filling Slabs

In filling slabs they should be partitioned off in strips by means of narrow boards set edgewise, and notched to pass the rods ; in this way the noon whistle rarely finds a section so incomplete that it cannot be finished in a few moments. If it is absolutely essential to suspend operations the joint should be made as near the centre of the span as possible, never near a support. On resuming work, the old concrete should be roughened, washed free of dust, and coated with rich cement grout.

Beam Boxes

Beam boxes should be well spaded along the sides, to free air bubbles and work a good face, and a handy tool can be made from 10 or 12 in. of 3-in. by $\frac{1}{8}$-in. mild steel drilled and screwed to a piece of "two by four." Another useful dodge is the use of a portion of expanded metal fixed in the same way, the meshes turning the particles over and over as it moves up and down.

Concrete should be placed as rapidly as possible after mixing, and never after twenty minutes, though even this is too long and quite unnecessary if the job is thought over beforehand.

Concrete left longer than twenty minutes should never be rewetted. The proper place for it is the rubbish pile.

After Filling the Forms

Many users heave a sigh of relief when the forms are filled, and turn to the next job, but there is still something to do if good results are

Fig. 14.—North Staffs Co-operative Dairy

Building of steel-frame construction encased in brickwork, all floors and roof flats being in reinforced concrete. Canopy runs around the building and is cantilevered in steel and concrete. Wall surfaces, both in and out, are in tints of ivory and green glazed brickwork. The condenser pool is provided over the cold store, the parapet walls around having liberal-sized openings fitted with wrought-iron panels for cooling purposes. (*Architects: E. T. Watkin, F.R.I.B.A., and F. Morrall Maddox, A.R.I.B.A.*)

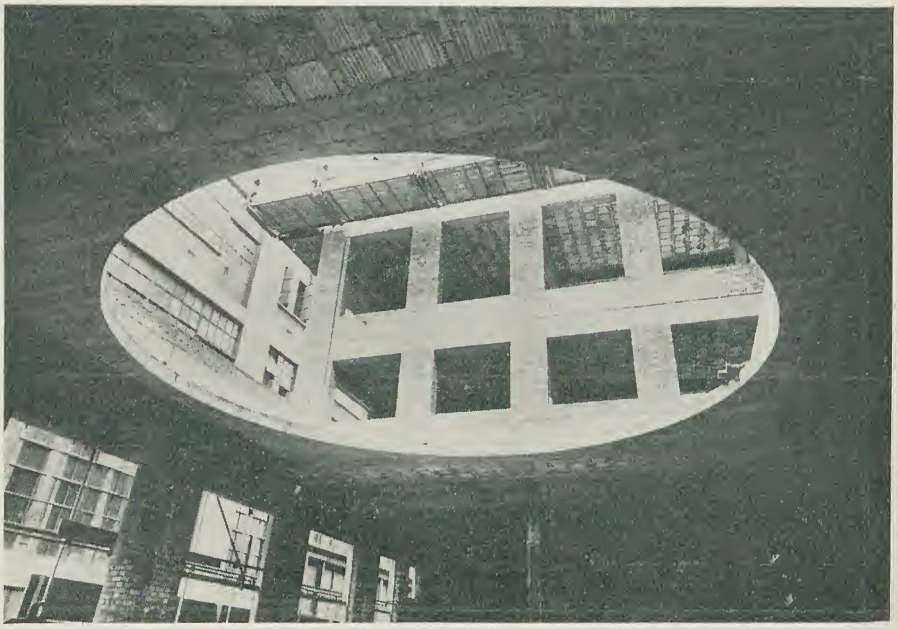


Fig. 15.—CONCRETE FLAT TO TAKE GLASS DOME

wanted. The concrete must be kept damp for some days, so that it may harden slowly. Buildings under construction are invariably draughty, and the resulting wind dries exposed concrete too rapidly.

Daily watering from a rose will produce hard, dust-free surfaces.

Pleading guilty to the lighting of fires to keep the thermometer at the level desired by the architect in cold weather, the writer knows that it is a shoddy way of doing a job. If work must go on, then the water for the mixing, and the aggregates, can be warmed, or more cement used, so as to get extra chemical heat to offset dangers of frost.

It is easy to obtain a reputation for careful reinforced-concrete work, and such a reputation is valuable to builders desiring contracts, and to foremen seeking employment.

Knowing something of the theory behind the design, it remains to use none but the best-quality materials ; to see that mixing is strictly to specification ; that the reinforcement is bent and placed in strict accordance with the drawings ; and, above all, that the concrete be rapidly placed after mixing, and thoroughly well punned.

Concrete construction is becoming rapidly lighter and more graceful, with a resulting need for the highest quality of workmanship to withstand the increasing stresses. Those who are prepared to apply the same degree of craftsmanship, which they now give to brickwork or joinery, to reinforced concrete, will achieve their own reward.

DOOR LOCKS

HOW TO SELECT AND FIT

THE following are the commonly used types of door locks, beginning with the night latch, which is essentially for an outside door. Its feature is the necessity of a key for entering, but exit from inside can be made without a key. As it is self-locking it has a further application to an office door, leading from a corridor, to lock the door in the owner's absence. A very suitable combination with it is a door spring, to hold the door closed when the latch bolt is held in, during the owner's occupation. In place of a door spring, or in conjunction with it, a " ball " catch is distinctly useful.

Dead Lock

A dead lock having no latch bolt is useless to hold a door closed as distinct from locked. Its purpose is for doors held closed by other means. Out-buildings are normally so fitted.

Two-bolt Lock

A lock (the term two-bolt is used but is really unnecessary) serves the purpose of holding the door closed by the latch bolt, which is knob-operated from both sides, and also has a dead bolt operated by key from either side. It is the usual fitting for house doors, as it provides the owner with security if he chooses to use the dead-bolt mechanism, and alternatively ease of entry by knob, when security is not sought.

Latch

A latch is a cheap mechanism for holding a door closed. It is frequently used on corridor doors which require no security, and particularly in bedrooms where the " jumbo " bolt (in a rim latch) provides security to the occupant without the cost of a key-operated dead bolt.

SELECTING A LOCK

Some of the points to remember in choosing a lock are given below.

(1) The largest lock that the door will carry, and the cost will stand, provides the greatest factor of safety.

(2) Don't build the door with both an inadequate rail and style so that it requires a special size of lock. Such a lock is not good value compared with a standard product, and rarely is as well designed or made.

(3) All other things being equal, choose a lock which has long shoots

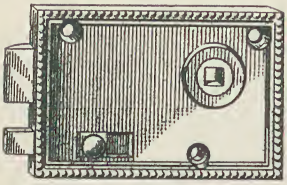


Fig. 1.—RIM LATCH

The bevelled spring latch bolt is withdrawn by a knob from both sides of the door. It normally includes the small thumb bolt shown which is known as a "jumbo" bolt, operated from the visible side only.

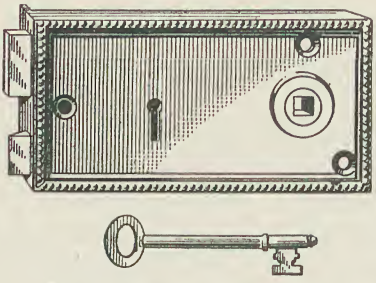


Fig. 2.—RIM TWO-BOLT LOCK

Bevelled spring latch bolt is drawn in from both sides by knobs. Square dead bolt is locked out and unlocked by key from either side.

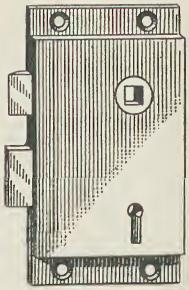


Fig. 3.—UPRIGHT TYPE OF RIM LOCK

(See also Fig. 2.)

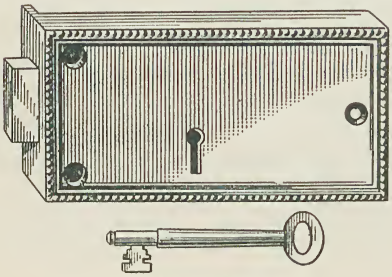


Fig. 4.—RIM DEAD LOCK

The square dead bolt is locked out and unlocked by key from either side. Note the absence of a spring latch bolt.

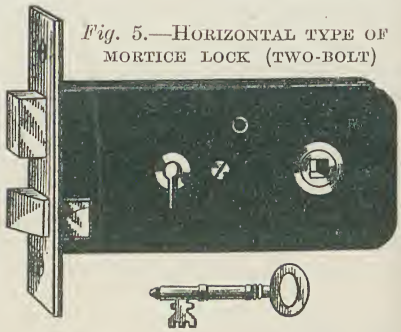


Fig. 5.—HORIZONTAL TYPE OF MORTICE LOCK (TWO-BOLT)

This is operated by knobs from both sides of the door, and key from either side.

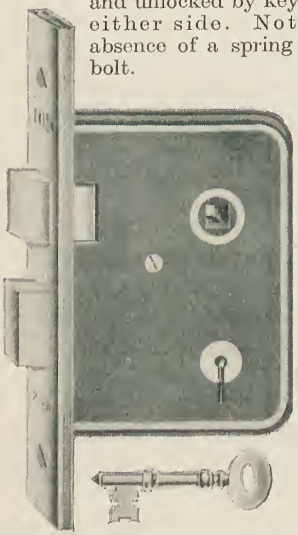


Fig. 6.—UPRIGHT TYPE OF MORTICE LOCK

(See also Fig. 5.)

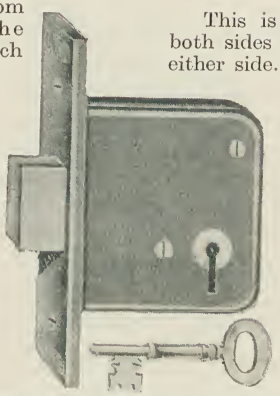


Fig. 7.—MORTICE DEAD LOCK

The square "dead" bolt is locked out and unlocked by the key from either side. Sometimes a "double shoot" lock is made where a further turn of the key doubles the previous shoot.

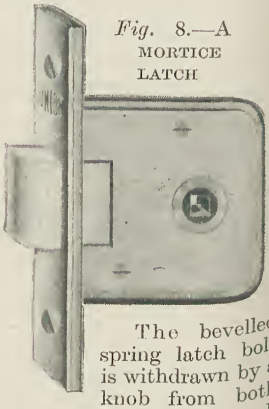


Fig. 8.—A MORTICE LATCH

The bevelled spring latch bolt is withdrawn by a knob from both sides. If instead of a knob outside the door there is a key, the latch becomes a *night latch*, then a catch is provided to hold in the latch bolt when not required.

on both dead and latch bolts. Five-eighths of an inch is a good dead-bolt shoot, and ½ in. is ideal for the latch bolt. To provide a good striking angle on the latch-bolt face the thickness (measured in the same direction as the door thickness) should at least equal the shoot. This gives an angle of 45°.

(4) A latch-bolt mechanism known as "easy action" is much used for knobs and is essential for lever handles. When the door is closed a light spring bears on the latch bolt, but when the knobs are turned a second spring is brought into operation. A lever handle imposes severe strains and will destroy a lock which is not designed for the purpose—"easy action" is one essential, strength is the other.

(5) Avoid a *deadlocking latch bolt.* This is a construction where the key, instead of operating on a separate dead bolt, locks the latch bolt so that it cannot be withdrawn.

(6) A master key and a pass key are quite different, but are often confused.

A pass key operates locks which are alike.

A master key will operate locks which differ from each other, each with its own servant or journey key.

Rim and Mortice Locks Compared

The original locks in the early days were screwed to the face of the door. This type of fixing still predominates in quantity, under the name "rim"—rim latch, rim dead locks, etc. The alternative type of fixing, that of morticing into the edge of the door, has certain advantages and also disadvantages, and as these affect the choice of the correct lock for a particular job they should be noted.

Mortice Locks

Mortice locks necessitate cutting into the woodwork to a considerable extent; they are made as thin as ⅜ in., but although the space within the lock is generally used to the best advantage, of necessity the action cannot be strong. Really good-quality locks are ⅝ in. or more thick, and this size necessitates a thick door. Whether the door is thin or thick the time taken to mortice into the door is the same; if anything, the better the door and the better the lock the quicker is the morticing. The advantages are—the key is short since it only goes half-way through the door and the lock is completely hidden; not only does this improve the appearance of the door, but it provides security.

Rim Locks

The rim lock, although visible on one side of the door, and therefore to a degree vulnerable, is rarely restricted in length, breadth or thickness. The mechanism can be strong and generally is.

The fixing is quick and does not in any way weaken the woodwork.

Its key, because it goes through the full door thickness, is longer and therefore more clumsy than that of a mortice lock.

FIXING A MORTICE LOCK

Door Construction

A horizontal lock is fitted into the centre rail, so the tenons in the rail need examination. In best-quality doors, two pairs of double tenons can be seen, but this is rare, and generally we find only two tenons, one at the top and one at the bottom of the rail. The mortice should be made equally between these. The usual width of the case of a horizontal lock is $2\frac{3}{4}$ in. (and upwards), and although it generally entails cutting into each tenon slightly, it cannot be avoided with this type.

If the door has a narrow rail, or one at an unsuitable height, an upright lock fitted into the stile is compulsory. The knob of an upright lock, vertically over the keyhole, is nearer the edge of the door than in the case of a horizontal lock, therefore the largest lock (measured from front of forend to back of lock) that the stile will stand should be used. A 4-in. stile will take a $3\frac{1}{2}$-in. lock, and such a lock should have a "backset" (distance from front of forend to centre of knob and keyhole) of at least $2\frac{3}{4}$ in. A lever handle is preferable at all times on such a lock, as it keeps the knuckles of the hand farther from the door frame.

Checking the Clearance

The door should be examined to see how well it fits the frame. The clearance between the edge of the door and the frame should at least equal the thickness of a penny, which forms a handy "feeler" gauge. If there is less clearance, the edge of the door should be planed before anything else is done.

If the door has warped to any extent, the stop of the rebate (if in one piece) or the slamming strip (if built up) should be corrected with a rebate plane, to fit the door equally top and bottom.

Marking Out the Mortice

A line is drawn down the centre of the door's edge, and with that as a centre line a rectangle is scribed, with sides $\frac{1}{16}$ in. more than the depth and thickness of the lock case.

A bit $\frac{1}{16}$ in. larger in diameter than the thickness of the lock case is adequate for boring. It is essential that the direction of the boring be true. Two things will help—first the door should be wedged firmly underneath; secondly, a strip of wood tacked to the side of the door, level, projecting about 8 in. (clear of the brace handle), will give a sight line. Boring over or under in depth is avoided if the length of the lock is compared with the bit, and the shank of the bit marked with chalk.

The top hole is bored first on the centre line at a height that cuts into the scribed top of the rectangle. The second hole is below the first,

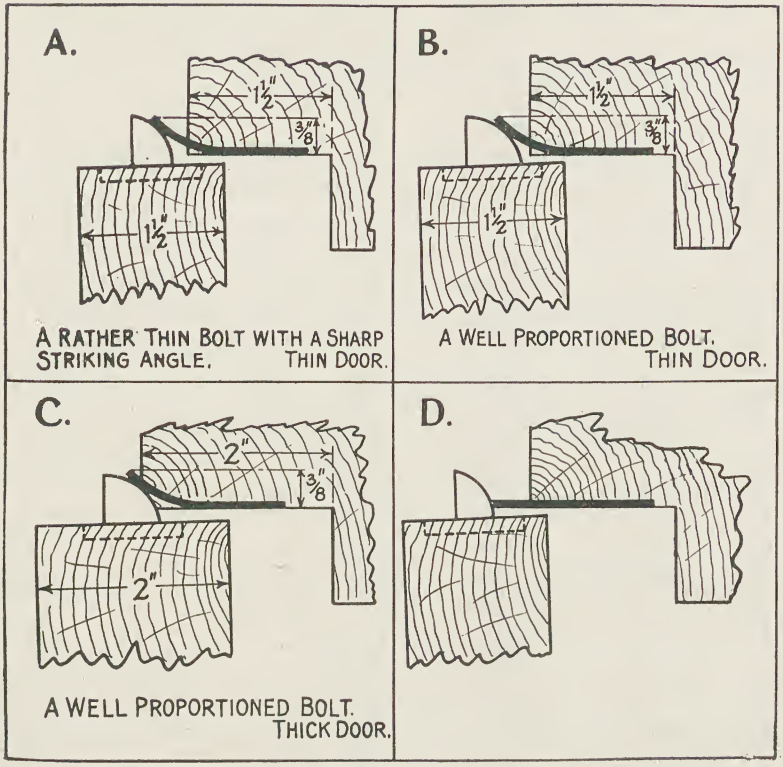


Fig. 9.—CROSS-SECTION OF THE FRAME JUST ABOVE THE LATCH BOLT HOLE

Diagrams A, B, and C show the correct bending of the striking plate lip. Diagram D shows a lip not bent. Whether the bolt be thick or thin the result is bad.

as near as possible to it. The nearer the holes the less wood to cut out after, but unless the boring is very true, better results are obtained if a space of at least $\frac{1}{8}$ in. is left between each hole. No great harm is done if the last hole substantially overlaps the bottom line, but it is preferable to space the holes to avoid this. The wood between each section is pared out and a router, or swan-neck chisel, used to help in any end grain.

Squaring Up the Morticing

The mortice should support the lock case and be a push fit, but one point must be noticed particularly: the forend must lie in absolute alignment with the edge of the door. If, for instance, the top of the forend has $\frac{1}{16}$ in. of daylight behind it when the bottom is touching the door edge, the mortice must be eased to correct it. When the forend lies flush its outline is scribed on the door edge. The lock is removed and the line cut with a wide chisel. The wood within is then removed, chip by chip,

with a small chisel, to a depth equalling the thickness of the forend. At this stage the lock should not be pushed hard into the mortice, as there is no means of pulling it out again.

Marking Key and Spindle Holes

The lock is now held to the side of the door, with the top of its forend at the same height as the top of the chiselled recess. The lock should be flat on the wood, with the back of the forend against the door edge. With a bradawl the centre of the key pin hole and the follower hole is marked on the door ; the lock is removed and new centres made a distance behind the others, equalling the thickness of the forend. These are the true centres. A $\frac{3}{8}$-in. bit is used for the keyhole and a $\frac{1}{2}$-in. bit for the spindle that goes in the lock follower. The bits should not go right through the door, only into the mortice. Exactly the same procedure is followed to mark out and bore the holes on the other side of the door.

The keyholes are now extended downwards to take the bit of the key with a pad-saw or a chisel $\frac{1}{4}$ in. wide. When chiselling, a block of wood placed in the morticed hole prevents splitting internally.

The final fitting of the forend into its recess can now be completed, because a spindle or screwdriver can be inserted through the $\frac{5}{8}$-in. hole into the lock follower to help the lock out again.

Removing and Replacing the Lock Forend

Most mortice locks have two forends ; one of steel is rigidly fixed to the case and is intended to carry the lock in the door by two wood screws. The covering forend hides the wood screws (and is also supposed to be removed when the doors are painted. It is held to the steel forend by two metal thread screws. After the lock has been placed in the mortice without its covering forend the wood screws are screwed in.

It will be noted that there is a considerable amount of play between the bolts and their holes in the steel forend. Distortion of the covering forend during replacement is avoided if the dead bolt is first locked out by its key, and the forend threaded over the projecting bolts. The covering forend has generally a slightly concave set, which ensures that the metal thread screws pull it down, so that it does not bulge in the centre.

At this stage, a temporary spindle and knob should be inserted.

FITTING THE STRIKING PLATE

Consideration should now be given to the striking plate that receives the lock bolts, and is always supplied flat. The door is closed slowly, and as the latch bolt is pushed in by the door frame, a line is scribed on the door frame where the top edge of the latch bolt meets it. This gives the level for the top of the hole in the striking plate which receives the latch bolt. It must be particularly remembered that doors drop and do

not rise, so that $\frac{3}{16}$-in. or so clearance, allowed by the lock manufacturer, between the size of the bolts and the size of the holes, must be at the bottom.

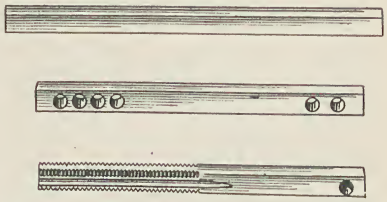


Fig. 10.—TYPES OF LOCK SPINDLES IN GENERAL USE

Top, Pitt's. Centre, if holes are plain, it is drilled through spindle (D/T). Bottom, Duce's : if holes are tapped, it is a drilled through and tapped spindle (D. T. and T.).

Measuring the Horizontal Position

The position horizontally in the door frame has now to be found. From the edge of the door which meets the slamming strip measure to the face of the latch bolt. If the rule is now placed in the frame, the same measurement from the slamming strip gives the position for the front of the latch-bolt hole in the striking plate. Measure the warp at this height (if there is any) and add to the above dimension about half the warp.

Cutting Out

The position having now been established, horizontally and vertically, the striking plate is held there and the outline scribed. Inside the line is chiselled out to let the plate in flush. The holes are then scribed and each hole chiselled out separately. In cheap work, one large hole is made in the wood in place of two smaller. It may be as well to note here that the function of a dead bolt is to *lock* the door, not wedge it, and for this reason most makers allow more clearance for the dead bolt than the latch bolt. A dead bolt fitted well should touch the striker nowhere.

Bending the Lip

The easiest operation in the procedure of fixing is that of bending the lip projecting from the main body of the striking plate, yet it is often left undone, and when done, is often skimped. This lip has now to be bent in a direction away from the door, in a metal-jawed vice, with strong pliers ; or it can be hammered over a hollow V in a piece of wood. A smooth arc is preferable, but a sharp bend where the lip joins the body is nearly as good. The bend back must be substantial ; for the lip to finish $\frac{3}{8}$ in. behind the face of the striking plate is ideal. The reason for this taking back the metal edge is to provide for the impact of the bevelled face of the latch bolt against a surface on the lip at approximately the same angle. Fig. 9 illustrates this point.

If the door is thin, it will be found that most of the lip projects beyond the door frame and the bend is "out in the air." If the lip is within the area of the wood, the frame must be cut back to receive the bend.

Hammering Not Recommended

A method very definitely *not* to be recommended is to hammer the lip over after the striker is screwed to the door frame. This does not bend it sufficiently without distortion to the rest of the striking plate.

The maker leaves it flat for two reasons. First, the direction of the bend is not known; secondly, the positioning of the plate in the frame would be more difficult.

MORTICE-LOCK FURNITURE

A mortice lock has a pair of knobs and keyhole escutcheons ; this is known as its furniture. In certain cases, the usual knob rose is replaced by a plate, which is large enough to cover the keyhole also ; this type is more general with upright locks, but since this type follows the same classification as the separate knob and keyhole escutcheon it will be sufficient if consideration is given to the one category.

Application of Pitt's System

A knob has to be held to something to take the pull, and in one case —known as Pitt's—it is attached to its rose, but is free to swivel on it. This means that the pull is taken on the rose with the spindle floating. If the door is thin, very little wood is available before the wood screws of the rose foul the lock case, so that the knob must be ordered on a plate in which the screws are pitched widely enough apart to miss the lock case. Pitt's fixing, although undoubtedly the best, is therefore limited to thick doors or, in the case of thin doors, to " Pitt's on Plate."

Fixing Pitt's

It is the most difficult of all forms to fit, yet it looks the easiest. The difficulty is caused by the necessity for obtaining true alignment of every part (not excluding the hole in the lock follower, which is not in the hands of the fixer). The distance that the spindle goes into the knob should be checked. In most instances, it will be found that the hole continues into the top of the knob. To reduce wear, the spindle is better left long, but a long spindle does not make alignment any easier.

The minimum length is found by inserting, as far as it will go, the spindle into the deepest hole in the pair of knobs, and holding it to the edge of the door. Any spindle projecting beyond the other side of the door more than $\frac{3}{4}$ in. can be cut off with a hack saw. The effect of leaving $\frac{3}{4}$ in. is that wherever the spindle may float to, into one knob or the other, there is a *minimum* of $\frac{3}{4}$ in. in each. In certain fancy designs of lever handle the hole is very shallow ; this is a bad feature, and, to make the best of it, the spindle must be as long as possible. The amount to cut off is found by checking against the door thickness both handles together on the spindle.

To find the best working position on the woodwork for the knobs, both

sides of the door must be tried at once. Put one wood screw in one rose and one in the other ; test the freedom of both knobs before continuing with the other screws.

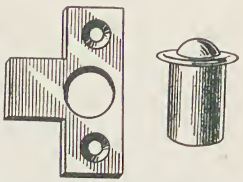


Fig. 11.—A USEFUL "PUSH OPEN" CATCH FOR A DOOR

Application of Drilled Systems

With all other forms of furniture the pull is taken on the spindle and that in turn pulls the knob on the other side of the door, doing no harm. These other forms are therefore much in demand for thin doors, and where a low cost is essential.

"Drilled Through" System

This has a spindle with plain holes. The knob has in its neck a grub screw with a special projection, which registers in one of the holes.

Drilled Through and Tapped

This system has a spindle with tapped holes. The screw in this case fits through a clearance hole in the knob neck.

There is little to choose between these two types, but they have one feature in common that is worthy of note—the spindle has generally two holes at one end and four at the other. These holes are of varying pitch—at one end of the spindle they are, say, $\frac{1}{4}$ in., and the pair at the other are $\frac{3}{8}$ in.

Fixing Drilled Systems

The following instruction will make the use of this unequal spacing clear.

The lock is waiting for its furniture—drilled through or drilled through and tapped. The end of the spindle having the pair of holes is inserted into one of the knobs, far enough to show the second spindle hole through the screw hole in the neck of the knob. A screw is put in loosely. The rose is slipped on, and the spindle is then put through the hole in the door and the lock follower.

The second knob and its rose is then placed on the spindle, and with good luck the hole in the knob neck registers with a hole in the spindle. If it doesn't, notice must be taken of the position of the nearest hole. If the knob is "too far on" by, say, $\frac{1}{16}$ in., it is taken off and a washer used between the knob and the rose. If, on the other hand, it appears to be half-way between the two holes, the spindle with the knob is withdrawn.

This knob is then moved out to the first of the pair of holes, and then placed in the door as before. Trial now with the second knob will show that although before it was half a hole out it now registers.

This is the reason and the effect of the spacing $\frac{3}{8}$ in. at one end and $\frac{1}{4}$ in. at the other.

Application of Duce's System

Duce is the last form of spindle to be described. It provides easy adjustment, but is unsuitable for heavy duty. In this case one of the knobs is permanently attached to the spindle; the other end of the spindle is screwed down its length for about 2 in. The sides of the spindle may be square, or two sides may be grooved.

The loose knob has a tapped hole, to agree with the screwing of the spindle. In its neck there is a grub screw. If the spindle is grooved, the screw will be pointed. If the spindle is square, the screw's end will be flat.

Fixing Duce's

The fixed knob with its rose is inserted into the lock follower from the outside of the door.

The other rose is slipped on, and the knob screwed on till it meets the rose. The grub screw is then tightened on to the flat of the spindle. If the spindle is grooved, notice should be taken during insertion whether the grooves are at the top and bottom, or sides, as the pointed grub screw must engage a groove and not a flat side.

Rose with Hidden Screws

In the last three types there is a design in which the screw holes in the rose are covered by the knob. In that case the knobs must be removed to put in the wood screws, but first the best working position of the roses is found and scribed so that the roses can be screwed on in that position after the knobs are removed.

Keyhole Escutcheons

Keyhole escutcheons for mortice locks generally have a hinged flap. The point to watch here is that the flap may foul the door frame, or the knob rose, before it can be turned far enough to insert the key. This is particularly the case with 5-in. horizontal locks, where the key and knob are closer together than in a 6-in. lock.

The remedy is in the choice of furniture having an escutcheon of suitable shape and a small knob rose.

FIXING A RIM LOCK

A rim lock, cutting away little or no wood, requires no consideration of the door construction, provided there is sufficient flat surface available to take the lock body. A few upright rim locks are used on such as glazed doors, but the vast majority are horizontal and are fixed on the centre rail of a framed door, or on to the boarding of a door ledged and braced.

Marking Out

After the frame has been adjusted to agree with any warp in the door, the lock is held in position with its forend against the door edge.

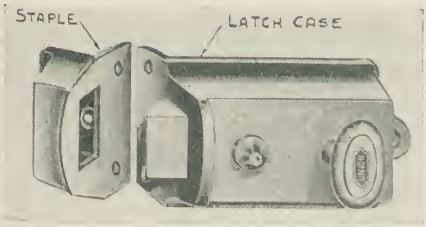


Fig. 12.—CYLINDER RIM NIGHT LATCH
Showing case.

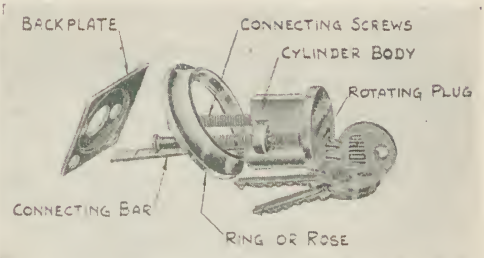


Fig. 13.—CYLINDER RIM NIGHT LATCH
Showing cylinder parts.

A line is scribed round the forend and the wood chiselled out within it to a depth equalling the forend thickness. The lock is again held to the door with the forend in this recess. The key and follower holes are marked through the lock, on to the woodwork, and the holes bored right through with bits $\frac{3}{8}$ in. and $\frac{5}{8}$ in. respectively. (The furniture has to be considered, if it is Pitt's, as described later.) The keyhole is then chiselled or sawn down to take the key "bit."

Screwing to the Door

The lock is again held in position and a bradawl used to start the wood screws. If the lock is flanged at its sides and the screw holes are in this flange, no care is necessary; but if the holes are in the body of the lock the bradawl must be nicely in the centre of the holes, particularly those in the lock cap at the back of the lock. The reason for this care is that a wood screw rubbing against the cap as it goes into the wood has a great tendency to spring the lock cap into the case and tighten the lock mechanism till it sticks.

Marking the Staple Position

In certain cases it will be found that the frame is left plain and flush with the door, then the staple is screwed on without further trouble. If the bolts are too loose, a line is scribed round the outside of the staple and all within chiselled out to a suitable depth. If, on the other hand, the lock bolts are not sufficiently free, the staple must be packed out with a wood shaving or cardboard; as in a mortice lock, and indeed in all locks, the *dead bolt* must have ample clearance.

Most door frames, although flush, have a moulding (architrave) on them, which has to be chiselled away to let the staple down on to the frame. It is best to cut straight to the frame and then make adjustments by packing or sinking deeper. The edge of the staple should be flush with the edge of the door frame, unless the clearance between the door and frame exceeds half the projection of the latch bolts; in that unlikely event the staple can project slightly over the clearance.

Staple with Flange or Lip

Some staples have a flange, or lip, intended to project down the frame, so that the screws are concealed when the door is shut. To fix such a staple it is held at the lock height with the back of the staple on the moulding and the flange inside the frame. A line is scribed on the moulding at the top and bottom of the staple, and at the back the outline of the staple is drawn on the moulding a distance from the staple equalling the flange thickness. The moulding is chiselled out within these lines down to the frame.

The staple is placed within this and the outline of the flange scribed on the door frame. Chisel out to a depth equalling the flange thickness, but do *not* go to the full line except at top and bottom. The door is then closed, with the staple held in position, and the recess for the lip is then made wider, by trial, till there is a nice easy clearance between the face of the latch bolt and the staple. If the body of the staple is then off the frame, the space is packed.

If the recess for the flange had been taken out to its full width in the first place it might have been found that it was necessary to bring the staple outwards to enable the bolts to engage and then a space in the recess would be left. Such filling, in a surface seen, is always to be avoided.

RIM-LOCK FURNITURE

Since the lock is on one side of the door, that side does not need a keyhole escutcheon or a knob rose. Therefore, a set of rim furniture consists of two knobs, one knob rose and one keyhole escutcheon.

Fig. 14.—SCRIBING THE FOREND OF THE CYLINDER RIM NIGHT LATCH

Note particularly that the follower is $\frac{1}{4}$ in. below the centre of the $1\frac{1}{4}$-in. hole. This is most important.

Pitt's Rim Furniture

As has been seen in the description of mortice furniture, the feature of Pitt's is that the pull of the knob is taken on the rose. This holds good with Pitt's rim furniture on the door side, but on the lock side no rose is available to take the pull. The knob on the lock side is permanently attached to the spindle and that takes the pull by one of two methods.

The cheaper employs a cotter pin behind the lock follower, where it revolves with the spindle in the clearance between the lock cap and the

door. If the clearance is insufficient, the door is recessed. This is better done before the $\frac{1}{2}$-in. hole is bored. The remaining knob, on its rose, slips on the end of the spindle.

The second method employs a spindle which is screwed on its corners (as Duce), and this screws into a large round nut on the other side of the door. This nut is recessed into the wood and is covered by the remaining knob on its rose. The effect of the nut is to screw the knob fixed on the spindle in and out, but as the pitch of the screwing is fine, the lateral movement is not serious.

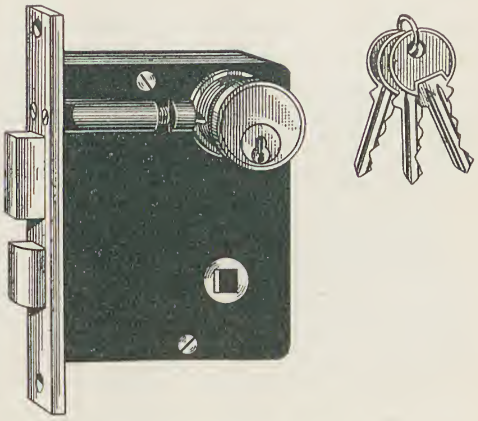


Fig. 15.—CYLINDER MORTICE LOCK

Other Systems

Drilled through, and drilled through and tapped, and Duce rim furniture, follow the same procedure as in mortice furniture, already described.

FITTING SPECIAL LOCKS

There are certain special locks which have features peculiar to themselves ; the most important of these are described below.

CYLINDER RIM NIGHT LATCH

This latch has a world-wide use, but examination of those on doors will show that the cylinder is frequently badly aligned with the latch case.

To Fix

A hole is bored $2\frac{3}{8}$ in. (or as otherwise directed by the manufacturer) from the edge of the door. The hole for most English latches is $1\frac{1}{4}$ in. in diameter—a bit of this size is almost essential in a tool kit.

The correct position of the latch case up the door style has now to be found. This is most important. If the cylinder body is inspected it will be seen that the rotating plug is not concentric with the outside face. In most makes the eccentricity is $\frac{1}{4}$ in. Now the latch case must be aligned with the rotating plug and not with the centre of the $1\frac{1}{4}$-in.-diameter hole. To effect this—the latch case is held to the inside of the door, its forend to the door edge, with the rectangular hole in the lock follower $\frac{1}{4}$ in. below the centre of the $1\frac{1}{4}$-in. hole (or measured another way—$\frac{3}{8}$ in. from the bottom of the $1\frac{1}{4}$-in. hole). This latter method of

measuring is perhaps the easier, as a piece of cardboard or wood chip $\frac{3}{8}$ in. wide can be used as a gauge.

The outline of the forend is then scribed on the edge of the door and the wood within the lines removed to a depth equalling the forend thickness. This, if correctly done, should bring the latch follower back into the vertical centre line of the $1\frac{1}{4}$-in. hole, but still leave the latch follower $\frac{1}{4}$ in. below the hole centre. The latch is now put on one side for the time being.

The cylinder, in its rose, is inserted in the hole, and the connecting bar at the back of the cylinder is marked for shortening to the extent that not less than $\frac{1}{2}$ in. and not more than $\frac{3}{4}$ in. projects through the wood. Less than $\frac{1}{2}$ in. would make it difficult to guide the connecting bar into the follower ; more than $\frac{3}{4}$ in. means that the connecting bar would tend to foul on the other side of the case carrying the knob, and although the knob is hollow, the connecting bar is better left short of it. The big connecting screws are then shortened as required. They need be only long enough to engage four or five threads in the lugs on the cylinder. If they are left too long they bottom against the face of the cylinder and distort the barrel in which the key plug turns. If the screws are shortened to an over-all length of $\frac{1}{8}$ in. less than the door thickness they will be suitable for any cylinder in the conventional raised rose. The cylinder is then fixed in position in the centre of the hole by the connecting screws.

The latch should now be placed in position, the connecting bar engaging with the latch follower. With the latch held to the door firmly the alignment should be tested by turning the key both ways. One inch and a quarter is a larger hole than is necessary for the cylinder body, so, if the key works stiffly one way, the alignment can be improved by moving the cylinder body within the hole.

If the mechanism works nicely, two wood screws should be put in to stop the back plate (which receives the connecting screws) from turning round. The latch is then screwed to the door. The staple is generally of the " flanged " type, so its fixing follows the directions previously given under the sub-heading " Staple with Flange or Lip."

A Warning

The small screw or screws which hold in position the cap at the back of the cylinder body where the connecting bar pivots must not be removed. A cylinder has 15 pins and springs which cannot, once displaced, be reassembled without special apparatus.

And a word of advice : blacklead is the only suitable lubricant for a cylinder mechanism. Rub a blacklead pencil along the top edge of any key which does not go in easily. Never use oil.

CYLINDER MORTICE LOCKS AND LATCHES

These, although not generally used in England, are increasing in popularity.

By slackening a small screw visible in the lock forend two or three turns, the cylinder can be unscrewed from the lock or latch. If, as is usual, a spring rose (and possibly a plate) is to be fitted, these are placed over the cylinder, which is then held to the edge of the door. The cylinder should then reach a distance corresponding to half-way through the wood. If it doesn't, the lock manufacturer must be asked to supply a shorter, or longer, cylinder. A cylinder too long *can* be packed, by a block with a hole in, under the head, unless a plate is used ; but it cannot be called a workmanlike job. Conversely, the ring of a cylinder that is too short *can* be let into the door.

Another and more often used method is to check the cylinder length and then mortice the door nearer to, or farther from, the cylinder side of door. This has obvious limitations and can be employed only when a lock has one cylinder ; some have two.

Fig. 16.—HOOK BOLT DEAD LOCK

This type is essentially for sliding doors. The striking plate must have sufficient sideways clearance to accept the bolt at the utmost limit of sideways variation of door position.

After the lock or latch has been inserted in the mortice, the cylinder is screwed in from the side. While the screw in the forend is being tightened the cylinder must be " rocked " slightly to feel that the screw is really engaging in the milled groove in the side of the cylinder.

If, on the opposite side to the cylinder, a finger turn is fitted, this must be free. Most makers leave plenty of clearance round the seating of the turn ; if it binds, the key owner can be locked out unintentionally and the lock will never be free from trouble.

REVERSING A LATCH BOLT

The latch bolt of a two-bolt lock is nearly always reversible. The adaptability of this varies in rim and mortice, as will now be seen.

Rim

In the instructions for fixing, the usual door with the lock inside, opening inwards, was considered. *Some* doors open outwards, with the lock still inside. The lock is fitted as described before, flush with the edge of the door, but now when the door is closed, it will be found that the lock fouls the slamming strip of the door frame. This has to be cut away to take the lock case before the door will shut.

In place of the staple a striking plate has to be used and this is let into the recess in the slamming strip.

The latch bolt is reversed before the lock is screwed into the door by removing the screws holding the lock cap in place, and turning the bolt

the other way up. Particular care must be taken that the follower, if dislodged, is replaced the same way that it was, because the horns or projecting arms on the follower are generally at different angles and of different lengths for a good reason.

Although a rim lock may have a reversible bolt it does not make it suitable for a right- and left-hand door; in other words, it is *not double-handed.* Therefore, the hand of the door has to be known and is defined: looked at from the outside, with lock inside, with bolts projecting to the left, it is a left-hand door; projecting to the right, is a right-hand door.

Double-hand Rim Locks

A "double-hand" rim lock has a keyhole "both ways up," and therefore *does* suit both a right- and a left-hand door. It may, or may not, also have a reversible bolt for a door opening in or out. Double-hand locks have an enormous sale, but should be confined to very cheap jobs.

Mortice

As distinct from rim, the reversing of the latch bolt in a mortice lock *does* reverse the hand, so practically all mortice locks have reversible bolts. With the bolt one way a lock is suitable for a door: Left-hand open in; right-hand open out.

And when reversed—Left-hand open out; right-hand open in.

To reverse the bolt of a mortice lock, the cap is detached from the case, but in certain types the cap is well fitted and difficult to remove. The lock should be held in the left hand, forend away, cap upwards, and the back corner of the lock tapped smartly with the handle of a screwdriver, in a downwards direction. This will lift the cap up slightly and enable a screwdriver to be inserted in the joint without damaging it. After turning over the bolt the cap should be fitted in at the front of the lock and lowered on to the top of the lock follower. A screwdriver in the follower hole will move the follower into its correct position and the cap will fall into place. The correct functioning of the mechanism should then be tested.

SELECTING AND FIXING IRONMONGERY FOR WINDOWS AND FANLIGHTS

WINDOW AND CASEMENT FITTINGS

WHEREVER joinery-made windows are used a certain amount of consideration has to be given to the types of fasteners that are to be fitted. In metal windows these are usually standard, but not so with wood sashes.

In the case of sliding sashes we have to consider the pulleys through which the sash cords run, the sash fastener to secure the windows, and the sash lifts. There are several types of these fittings, some showing a difference in quality and some a difference in the method of operation.

How to Select Sash Pulleys

A sash pulley should be chosen for its strength and ease of running, and it is recognised that ball-bearing pulleys are the best. Again, while one must not despise the old type of pulley made to receive the sash cord, there are on the market to-day various types incorporating a chain and cogged wheel. Opinions are divided as to whether these latter types have any advantage over others. It is certain, however, that slipping is prevented, but possibly at the sacrifice of quietness.

Fixing a Sash Pulley

A sash pulley is fixed in the side of a cased frame and in such a position that when the window is pushed either up or down to its maximum position the counterweight on the end of the sash cord does not foul the bottom of the frame.

The seating of the pulley should be housed into the frame so that its surface lies flush, the small projecting portion of the pulley riding in a groove in the side of the sash. Take care that the size of the sash cord used is the correct size for the pulley ; this is often a source of trouble, as a thinner cord will ride over the edge and jam between the sides of the pulley and the sides of the frame, whereas a too-large cord will prevent easy running.

Sash Fasteners

Sash fastener is the name given to the small fitting usually placed on the top bar of a bottom sliding sash and on the top of the bottom bar of

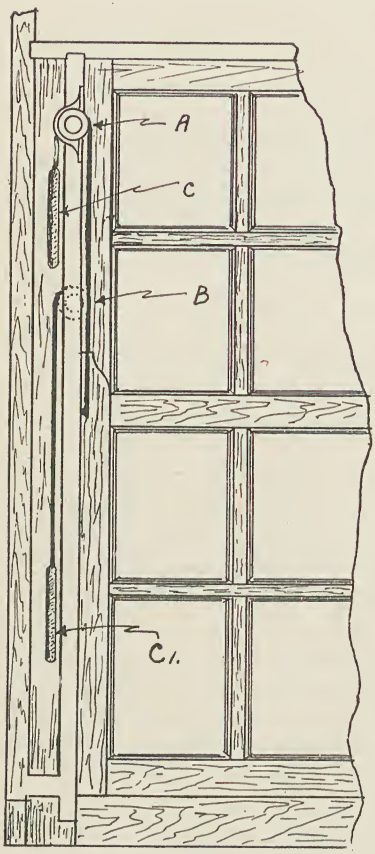


Fig. 1.—FIXING A SASH PULLEY

A sash pulley should be placed in the position A in the above illustration, so that when the window is raised the counterweight C has room to travel without fouling the bottom of the casing. If it were placed in the position B the weight C1 would not be able to travel this distance.

the top sliding sash, and so fitted that one piece engages in the other, thereby preventing the window from being opened from the outside. Here again we find different forms ; some are simple in their operation, but this also applies to the burglar's activities, as it was found that the old-type fastener could be easily opened by means of a knife blade inserted between the sashes.

Burglar-proof Sashes

To prevent the window being opened after this was done the old method was to use a pair of long thumb-screws screwed from the inner face of the top bar of the lower sash through to a connecting plate on the bottom bar of the top sash, thereby preventing either sash from being moved. This was a clumsy method and also took a certain amount of time. There are on the market sash fasteners which prevent this unauthorised opening, and their methods of fixing are not far removed from the old type.

Sash Lifts

Sash lifts can be divided into three types : surface fixing, flush fixing, and the pulley type. The former consists of nothing more than a handle of various shapes which can be screwed to a bottom sash to provide a hand hold.

Flush lifts, however, require a little more attention, and, as their name implies, are housed flush with the surface of the sash. Where these are fitted in pairs the distance apart is not material provided that if the sash is a wide one they are not fitted beyond the comfortable reach of a person's extended arms. For appearance' sake, however, they should be fitted evenly in the thickness of the bottom bar.

Fitting a Flush Lift

Carefully measure the size of the lift to be fitted and, having decided upon the position, mark a centre line in that position and mark half the

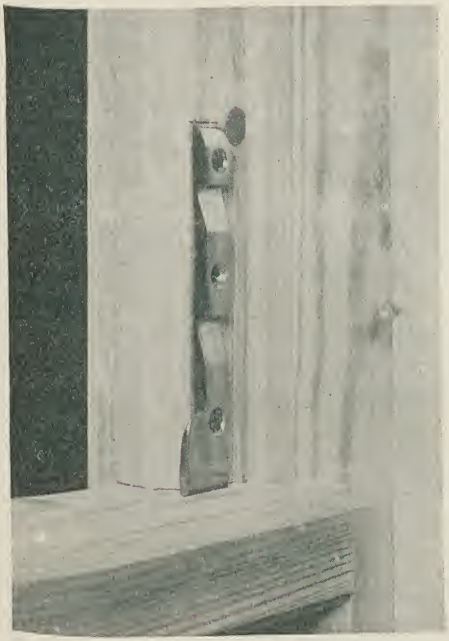


Fig. 2.—FIXING PULLEY LIFT

The first operation is to place the locking plate in position on the top sash, as shown. Next place fastener on bottom sash, as in Fig. 3.

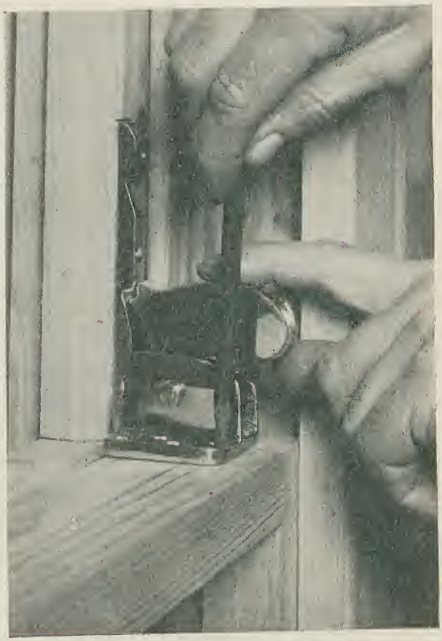


Fig. 3.—FIXING PULLEY LIFT

The fastener is then placed on the top of the bottom sash so that it will engage in the locking plate when in the closed position, as illustrated.

length of the lift on either side of this line, squaring off two vertical lines with a square. Next mark a horizontal line dead centre in the width of the sash bar and measure half the width of the lift either side of this line. If the lift is a rectangular one, these four lines give the exact position for the sinking, and the wood should be removed with a chisel for a depth equalling the thickness of the metal.

In the centre of such a sash lift will be found a recess for the fingers, and this naturally must be sunk deeper into the wood. A proper housing must be made, therefore, for this too, making it only sufficiently large to allow an easy fit. Otherwise, if too much is removed, one may find that there is nothing left to provide a hold for the fixing screws in the corners. All this may seem very unimportant, but these points make all the difference between a workmanlike and an unworkmanlike job.

Pulley Types

Where sliding sashes are used, which are possibly large and heavy, the two types just mentioned are not suitable for the top sashes, and these should be raised or lowered by means of pulleys or cords. These

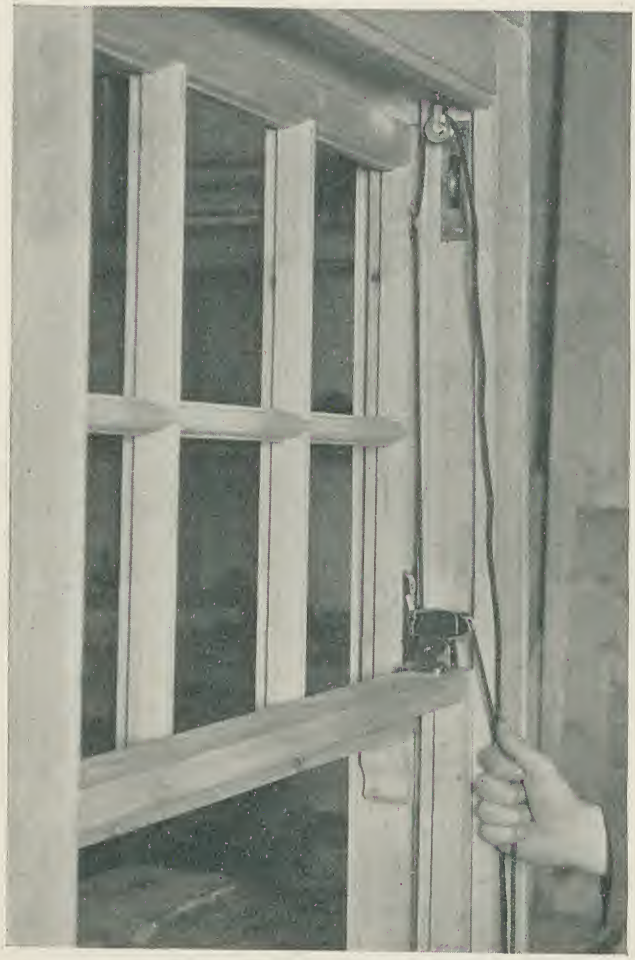


Fig. 4.—FIXING A PULLEY LIFT

This shows the lift fixed complete. To close the window, the cord that passes over the top pulley is pulled. The other cord is used for opening, and passes under and over respectively on the two pulleys of the fastener. Pulling the latter cord compresses the spring and pulls the fastener away from the locking plate, enabling the pulled cord to draw the sash downward. The left-hand side of the sash is similarly fitted with a top pulley and cord plate, but without the fastener and locking plate, thus giving an even pull by two hands to raise or lower the window. (*Stedall and Co. Ltd.*)

are usually fitted in pairs, one on each side of the window, to give an even pull, and a locking plate is so incorporated that when the window is closed it is self-locking, and yet when opened to a certain distance for ventilation is secured in that position and prevented from being moved.

Fixing a Pulley Lift

First place the fastener on the top of the top bar of the lower sash and on its extreme edge, in such a position that it will engage in the locking plate, which must be screwed on the upright of the top sash, as is shown in Fig. 2. These two members are then screwed in position. Next screw one pulley into the head of the frame in a position that is immediately vertical over the pulley in the bottom fastener. It is essential that this pulley must be central over this fastener, otherwise some power of the lift will be lost by reason of its being unable to exert a straight pull. The corresponding pulley should be placed in a similar position on the other side of the head of the frame.

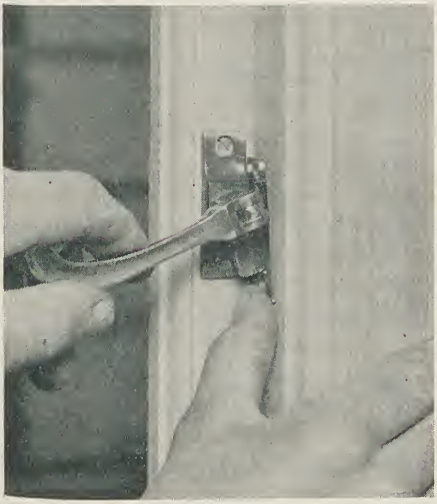


Fig. 5.—FITTING CASEMENT FASTENER

The cockspur is first screwed to the sash. With sash in closed position, gently force cockspur into frame with plate held so that tongue of cockspur does not foul bottom of the slot. Position of plate is then marked from impression left in wood.

Fig. 6.—FITTING CASEMENT FASTENER

After the operations explained in Fig. 5, a mortice is cut in the frame to receive the tongue of the cockspur, and the mortice plate housed to allow it to lie flush with the surface of the frame. The mortice plate is then screwed into position.

Next take four ends of cord and pass two through each of the cord plates. With some of these, provision is made for fixing the cords on the bar. With others, the cords must be knotted before screwing the cord plate to the uprights of the sash in a position at about two-thirds of its height but level with each other horizontally. Now pass one each of the cords over the pulleys in the head of the frame. The remaining cord on the fastener side is passed under the pulley, through the operating catch, and over the other pulley.

Now test by pulling the two shorter of the cords, and these should release the catch and draw the sash downward. A pull exerted on the other two cords should raise the sash, and if the fastener has been properly fitted it will automatically engage without any further attention from the operator.

Casement Window Fastenings

In this type of window the question of raising and lowering is non-existent, but merely the fastening in a closed or open position. For the former a fastening known as a cockspur is used, and for the latter a casement stay. Of the former the type most used is that having a plate which is fitted over a mortice cut in the casement frame, and the tongue of the cockspuris fitted to it. When selecting one of these, be sure to get one with a good, bold handle.

There are plenty on the market at ridiculously low costs, but if compared with one for which a few pence more is given it will be noticed that the material has been skimped to such a degree as to make it difficult even to hold firmly in one hand.

Fitting a Cockspur

When fixing a casement fastener the cockspur should be screwed in position on the sash in such a position that a fair amount of the tongue will engage in the mortice and not merely the point. When this is done the position at which it hits the frame should be marked with the mortice plate held in position, to ascertain that the tongue will not foul the bottom of the plate as it is withdrawn. The suitable position having been found, scribe around the inside and outside of the plate at this point, cut a sufficiently deep mortice in the centre position first, and then remove sufficient of the wood around it to house the plate.

If the mortice plate supplied has its opening wider than the thickness of the tongue (which should not be the case, except for slight clearance), the mortice plate must be fixed in such a position that the cockspur will tend to draw the casement closely shut. This is done by setting the plate a little farther away from the sash towards the inside of the room.

Casement Stays—the Old Type

The oldest type of casement stay is one that employs a hinged bar drilled at intervals with holes made to fit over a pin fixed on the bottom of the frame. The back hinged portion of the arm is fixed to the sash, and when the window is opened the pin is made to engage in any one of the holes at will, thus holding the sash firmly in given positions. In the use of this type it is impossible to hold the window in " any " position, more especially at the " slightly open."

Sliding-bar Type

There has, therefore, been designed a casement stay with a sliding bar and a thumb-screw, by means of which the bar is clamped at any position along its travel. How the bar is made to travel is a matter of manufacture: in some cases it is telescopic, in others it slides through a slotted member fixed to the bottom of the frame.

Fixing the Stay

When fixing the former variety one or two pins may be used, but two are recommended. Study Fig. 7, which shows the figurative positions of a casement opening on one pin only, and then study Fig. 8, which shows the same casement opening on two pins. It will be noticed that in the latter a greater number of positions is offered than by the use of one, and further, the extra pin helps to draw the casement closer by preventing the bar slightly swinging on the axis that would be provided by one pin only.

A Friction Casement Stay

Among the many designs for casement stays the "Woodlock" patent "stay-put" fitting has many uses, although its principle, that of applying friction to the hinge of the sash or door, is the same in most of them. There are two patterns of this particular style of fitting, one with an adjustable joint and the other without. The adjustable scheme is the better, and makes only a slight difference in the cost. The first-mentioned type has a hinge bolt

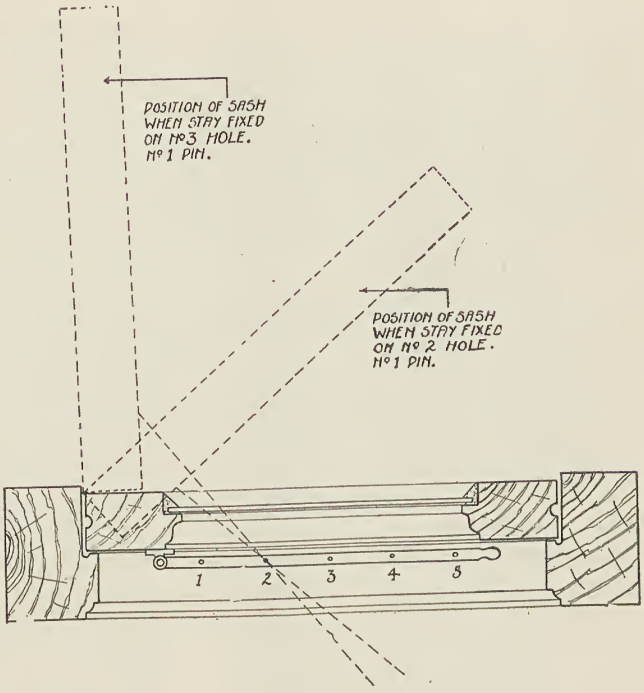


Fig. 7.—Fitting casement stays

The above illustration shows the limited opening positions when a casement stay is fixed with one pin.

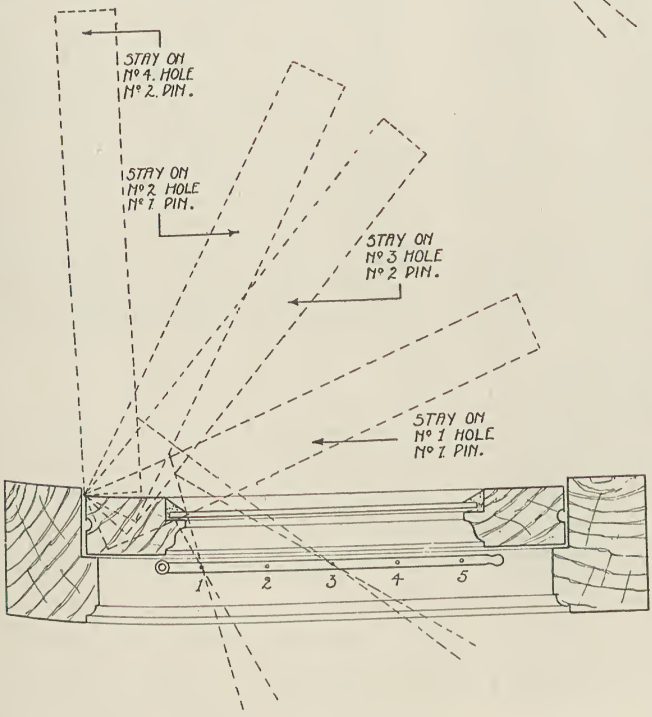


Fig. 8 (*below*).—Fitting casement stays

If a casement stay is fitted with two pins, the relative opening positions are increased as against those shown in Fig. 7.

Fig. 9.—FRICTION CASEMENT STAY WITH WINDOW OPEN

with winged nut, by which the pressure on the fibre washers contained in the friction joint may be altered to any desired amount. The joint of both is also designed in such a way that the continued movement of the hinge cannot unloose any of the moving parts which provide the friction.

Fitting Friction Stay to Door

For a casement sash or a door that is particularly subject to wind—most are, by the way—and which is required to be left in a partly open position, this fitting can be recommended. French folding doors which open to a garden are an example of this, and also almost all casement window sashes. In the case of doors the fittings would be placed at the top ; and the projection of the fittings inwards from the face of the doors when they are closed must be considered in respect to any curtain-hanging schemes that may exist or are proposed.

The fitting is shown in Fig. 9 open. The two arms of the stay are as nearly as possible directly over each other in the former position, and the mechanism is provided with stops which limit the opening of the sash.

To choose the correct position of the fitting for its attachment to the sash and the lining of the opening, it may be clamped to an ordinary 2-ft. rule as shown in the accompanying Fig. 10. Slacking off the friction joint, it may be placed in various positions, and the angle of movement directly observed. The distance of the fixings on both parts of the window may also be read off in inches from the centre line of the hinge.

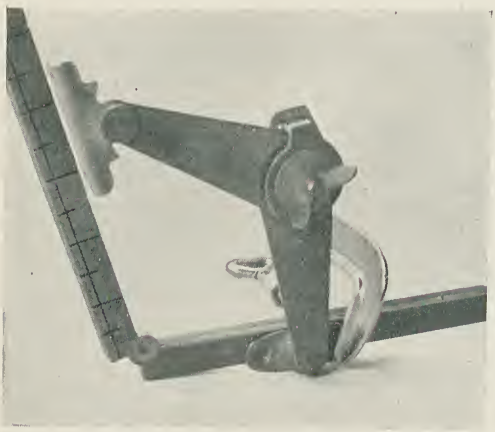


Fig. 10.—FINDING CORRECT POSITION FOR FITTING TO CASEMENT

For a "top-hung" sash, the movement required is usually less than in the ordinary case, i.e. for a door or window hinged at the side,

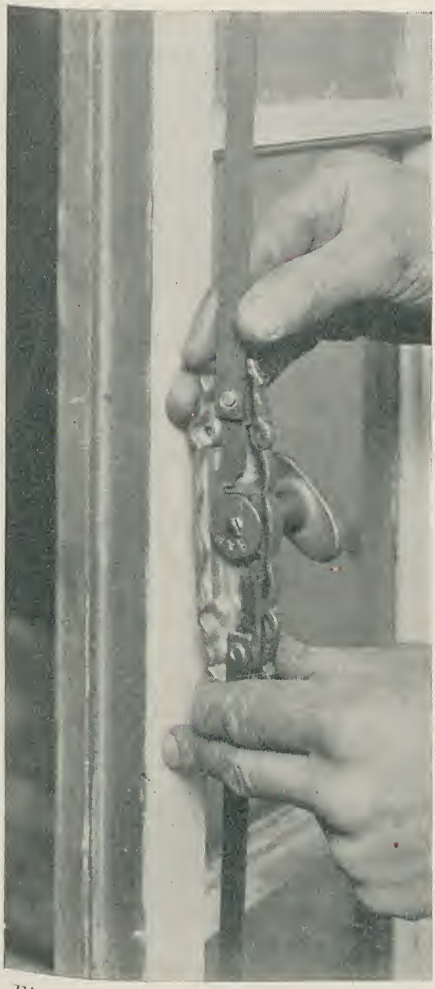


Fig. 11.—FITTING ESPAGNOLETTE BOLT

The first operation in fixing the bolt. The two sliding rods are placed on the pins at the back of the handle and the whole then screwed to the door. The bolt is placed on the door that holds the inner rebate in position.

Fig. 12.—FITTING ESPAGNOLETTE BOLT

The next step in fixing the bolt. The keepers are placed at equal distances along the length of the rod according to their number. Finally the keeper is drilled in cill, if doors fold over rebated cill, or special keeper is provided.

and therefore the fitting may be placed farther away from the hinges.

Using as a Casement Lock

The " Woodlock " fitting may be used as a casement lock by fixing $2\frac{3}{4}$ in. from the hinge post of the sash with both arms directly over each

other when the window is closed. By swinging the fitting over the centre the sash is locked. This is an advantage which will, however, not dispense with the usual casement fastener, and applies to the use for ordinary windows only. An extra-heavy pattern of this fitting is made for doors larger than those used for domestic purposes.

If a top-hung sash is very wide in comparison to its depth, two stays, one on each side, are recommended.

CASEMENT DOOR FITTINGS

Casement doors differ in action from casement windows in that there are a pair of doors hung folding and rebated at the meeting styles, and there are several methods of fastening. The cockspur is useless unless employed in conjunction with bolts. If it is desired to use the cockspur, then a pair of bolts must be fitted, one at the top and one at the bottom on the first closing door, the second door closing over the rebate. A cockspur can be used by having a hook plate in lieu of the mortice plate described.

Whether the bolts used are straight or necked depends upon the formation at the cill and head of the frame. If these are rebated and the casements open outward, then necked bolts should be used to give the best job, although the writer has seen the rebate cut away and an ordinary barrel bolt placed sufficiently low on the door to engage in the body of the cill. This is not practical carpentry, but bodging.

If the casements open inward and the cill projects above the floor, the inside face of the door being flush with the back edge of the cill, then a barrel bolt and its keeper can be used. Again, if the back edge of the cill is flush with the floor and the casements open inward, a barrel bolt and eye plate placed on the floor can be fitted.

Fitting Espagnolette Bolts

It is at all times doubtful, however, whether the cockspur is a satisfactory fastening for casement doors, and there is no doubt that the espagnolette bolt holds the premier position. It is true that the initial cost is greater, but the method in which it does its work is sufficient recompense for this. An espagnolette bolt fitted to a pair of casements provides a fixing at the top and bottom of both doors at once by reason that the first closed door cannot move, as the outer rebate holds it in position, and the bolt is fitted to this second door.

There is nothing difficult in the fixing of an espagnolette, the most important factor being perfect alignment. The bolt should be fitted perfectly upright and the brackets or fixing pieces placed in their true relation to the sliding rod.

With some of the more elaborate patterns it is well nigh impossible to fix these bolts in any but the correct method, as there is sometimes a solid casing from top to bottom, but in the cheaper forms where bridges are used

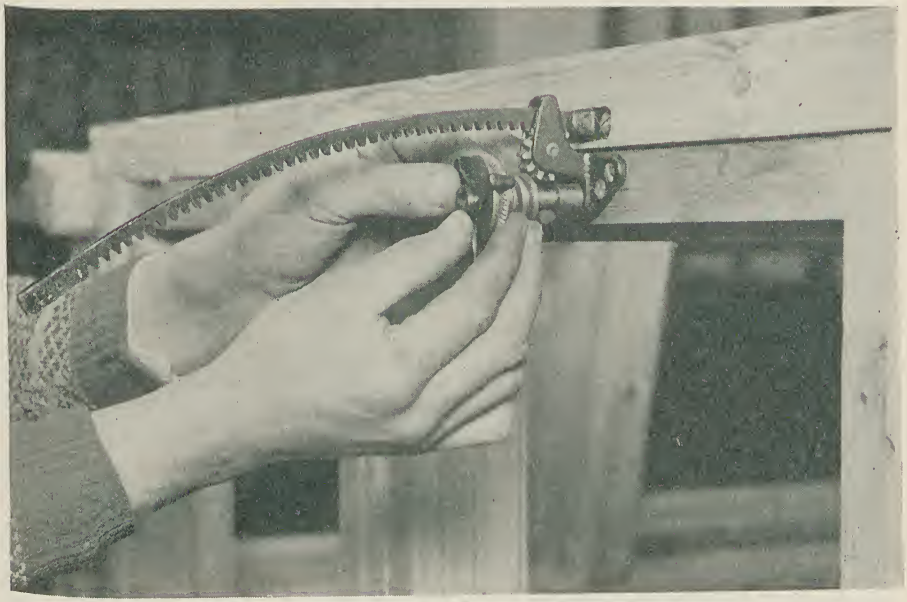


Fig. 13.—FITTING LEGGOTT'S FANLIGHT OPENER

A Leggott's fanlight opener for a bottom-hung fanlight opening inwards is shown being fitted. The mounting is first dissembled to allow access to the screws, and is then fixed in position as shown.

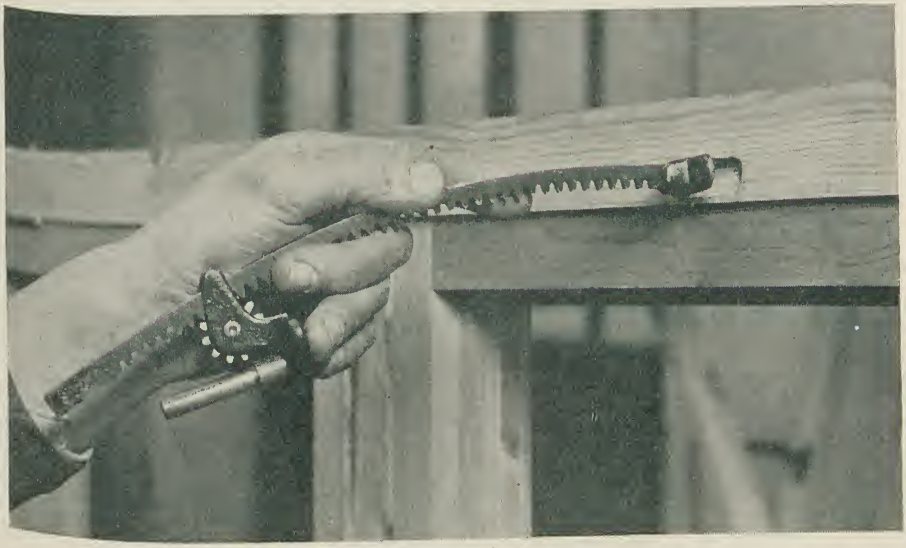


Fig. 14.—FITTING LEGGOTT'S FANLIGHT OPENER

Where the sash is recessed, the hinged back plate must be housed to the frame of the fanlight so that its back edge is in the same vertical plane as the face of the sash, as is shown above.

Fig. 15.—"SHERIFF" FASTENER IN POSITION ON TOP-HUNG OUTWARD-OPENING FANLIGHT

The position and method of fixing are clearly seen.

at intervals, unless these are fixed in true relation, the sliding bar will have a tendency to bind. The methods of fastening must again differ according to the specific surroundings; the top and bottom of the bolt can be made to shoot either into a mortice cut into the head of the frame and in the cill, or into a keeper provided.

IRONMONGERY FOR FANLIGHTS

Fanlight Openers

In describing fanlight openers we will confine ourselves to those that actually assist the opening, although, as an example, a fanlight catch operated with cords used in conjunction with a pair of quadrants is really a fanlight opener. There are, however, mechanisms that can be fitted to fanlights which will open or close them to any desired pitch, whether they be top or bottom hung, vertical or horizontal, inward or outward opening. As there are innumerable makes to suit each of these conditions, chief principles must suffice.

Size or Type of Opening	*Distance of Travel*	*Length of Bar*
Fanlights up to 2 ft. square	10 in.	12 in.
Ditto up to 3 ft. square	15 in.	16 in.
Heavy Fanlights	18 in.	21 in.
Skylights up to 2 ft. by 1 ft. 3 in.	10 in.	12 in.
Ditto up to 3 ft. by 2 ft.	15 in.	16 in.
Heavy Skylights	18 in.	21 in.
Extra-heavy Skylights	21 in.	24 in.

Leggott's System

The first, and that in most common use, is known as Leggott's system, and consists of a worm—revolved by means of an endless cord—which, in its turn, revolves a cogged wheel; this wheel, in its turn, travels along a serrated bar. In this type the cogged wheel and worm are placed on a mounting and the mounting made a fixture to the frame of the fanlight. As this mounting is fixed, allowing only the wheel to revolve, the serrated bar must move inward, outward, upward, or downward any distance according to the number of times the wheel is revolved and the type of opener used, those travelling upward and

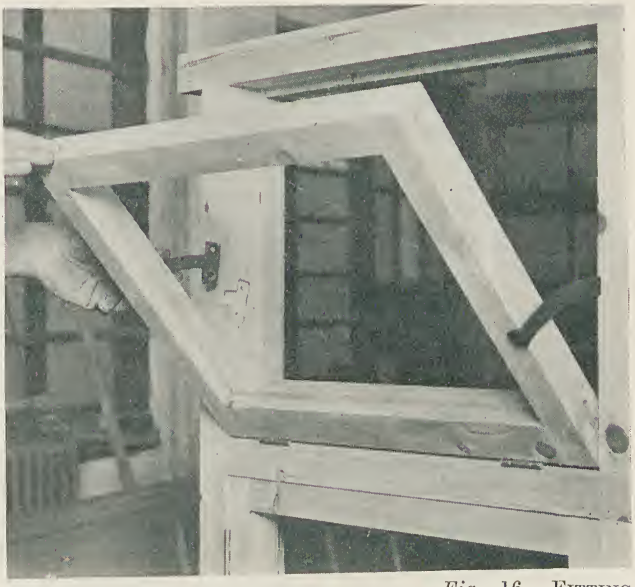


Fig. 16.—FITTING FANLIGHT QUADRANTS

Fanlight quadrants are mostly fixed to fanlights opening inward, unless the fanlights open outward into an area sheltered from the weather. The fixing plates are housed in the side of the frame in the position shown above.

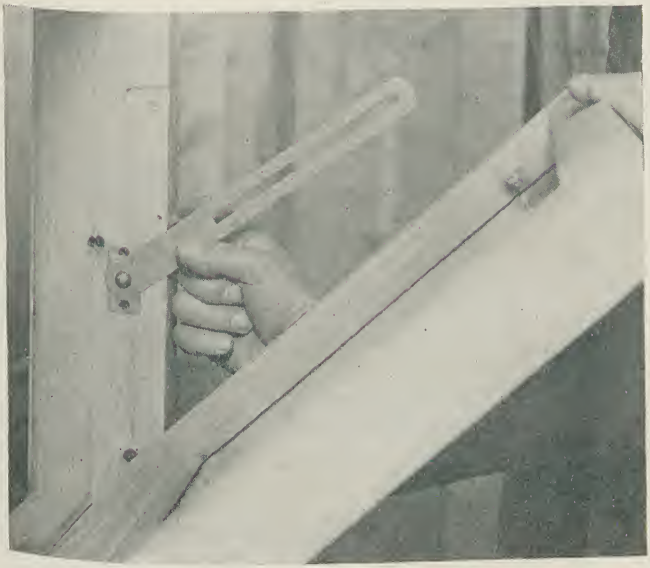


Fig. 17.—FITTING A SHADBOLT STAY

The stay is folded out of view when fanlight is closed. Riveted end of arm is housed to inside of frame, as shown, while sliding end is attached to sash by means of screw, a loose plate being housed into side of sash.

Fig. 18.—TELESCOPIC FANLIGHT OPENER
Showing fanlight being opened by long arm attachment. (*Skylux Ltd.*)

downward being known as skylight openers. The usual lengths of these serrated bars, the distance to which they open, and the typical size of fanlights or skylights for which they are to be used is given in the Table on page 460.

Fitting a Fanlight Opener

The actual fixing of any of these openers should present no real difficulties. In the case of a bottom-hung fanlight opening inward it is first essential to fix the mounting holding the worm in position on the centre of the top bar of the fanlight, which should then be closed. The serrated bar has a back plate hinged to it.

This back plate is screwed to the frame, and the action of the hinge allows the bar to drop and remain engaged loosely with the cogged wheel as the angle of the fanlight varies during its opening. It should also be mentioned that the bar is slightly curved to correspond with the arc described by the fanlight. The same principle of fixing is universal throughout Leggott's system, whichever type of opener is used.

Fitting a " Sheriff " Opener

There are other types of openers, some of which give a more limited amount of opening both in space and number of positions, and one such is known as a " Sheriff " patent fanlight opener. The space of opening when using a " Sheriff " opener depends upon the position at which it is fixed, for while the maximum amount of opening can be obtained when it is fixed at a point nearest the hinges, the ease with which it is opened is considerably lessened.

In large works, systems of gearing are used so constructed as to open several fanlights or skylights at once, but these are usually supplied and fixed by specialist firms and rarely come within the scope of the carpenter and joiner.

Fanlight Stays

While on the subject of fanlights, other articles of ironmongery used in conjunction with these are various types of fanlight catches, quadrant, roller, and other stays.

Fanlight catches are the simplest of all stays, the fixing plate being housed into the side of the frame with its surface

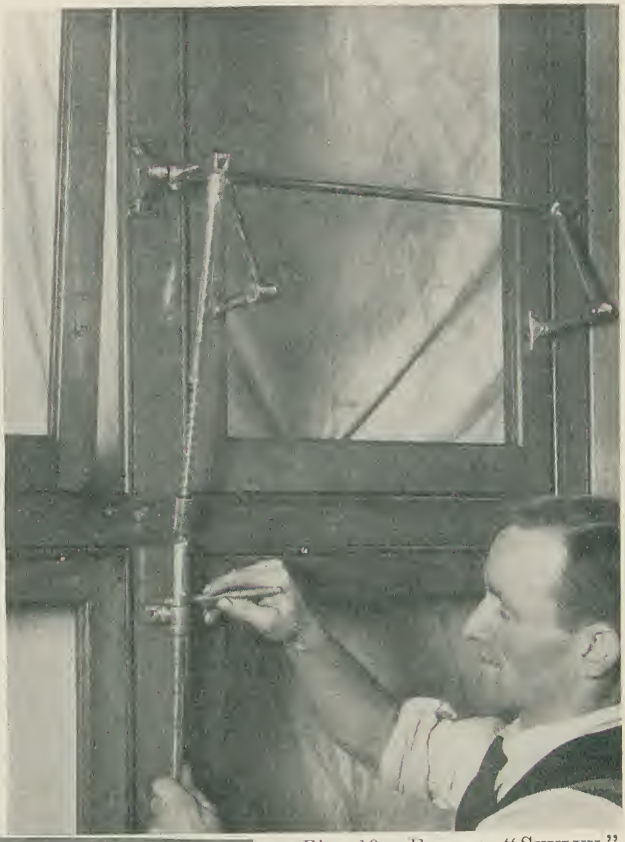


Fig. 19.—FITTING "SKYLUX" TELESCOPIC MULTIPLE GEAR TO FANLIGHT

Marking position of the telescopic pull member, after which it is screwed down. It is important to note that the light should be in the closed position and the telescopic pull member should be out to its full length when fixing the latter. If this is not done, the extent to which the fanlight can be opened will be curtailed.

Fig. 20 (*below*).—FITTING "SKYLUX" TELESCOPIC MULTIPLE GEAR TO FANLIGHT—FIXING THE GEAR BOX INTO POSITION

This is simply attached to the end of the telescopic pull member and screwed, as shown. Multiple gear can be made to operate a number of fanlights in line by extending the rolling bar and fitting the necessary brackets and elbows to each sash. Centre- and bottom-hung fanlights can also be operated by means of the gear illustrated in Figs. 19 and 20.

flush. The fanlight is held closed by means of a spring catch operated by hand or longarm. These quadrants can be obtained in various sizes, each giving a different angle of opening. They have the disadvantage, however, of being unsightly, as they always remain in one position and cannot be tucked away. To overcome this, another type is used having a slotted bar riding on a screw. This bar is fixed by means of a pivot to a back plate housed on the inside of the frame, and a plate having a detachable screw is fixed on the side of the sash.

One type can only be used for fanlights hung at the bottom. There is another type which is an adaptation of the same principle, but the top edge of the slot in the bar has grooves or notches cut in to prevent a top-hung fanlight closing of its own accord.

Fixing the Stay

In fixing one of these stays, the position varies according to the angle at which it is desired that the fanlight shall open, in conjunction with the length of the stay. Having determined this position, place the stay on the inside of the stile of the frame of the fanlight and mark the position of the back plate, at the same time making a point where the bottom of the slot occurs. Make a small sinking of sufficient size to accommodate the back plate so that the surface lies flush.

Now measure the distance from the top of the inside of the frame to the point marked at the bottom of the slot, and measure this same distance on the outside of the sash. This point gives the centre of the plate with the detachable screw. Remove the screw from this plate and place it over this point, which will be seen through the centre hole, and again mark out the size of the plate, sinking flush as before. Having placed the fixing screws in position, raise the bar so that the slot is immediately over the hole in the plate on the side of the sash, and replace the screw.

If an attempt is now made to close the fanlight it may be found that this screw fouls the inside of the frame and a small slot must be cut to receive it. The fanlight should be fitted with a pair of these stays, otherwise the weight will tend to twist the frame when it is open.

PRACTICAL NOTES ON PLYWOOD

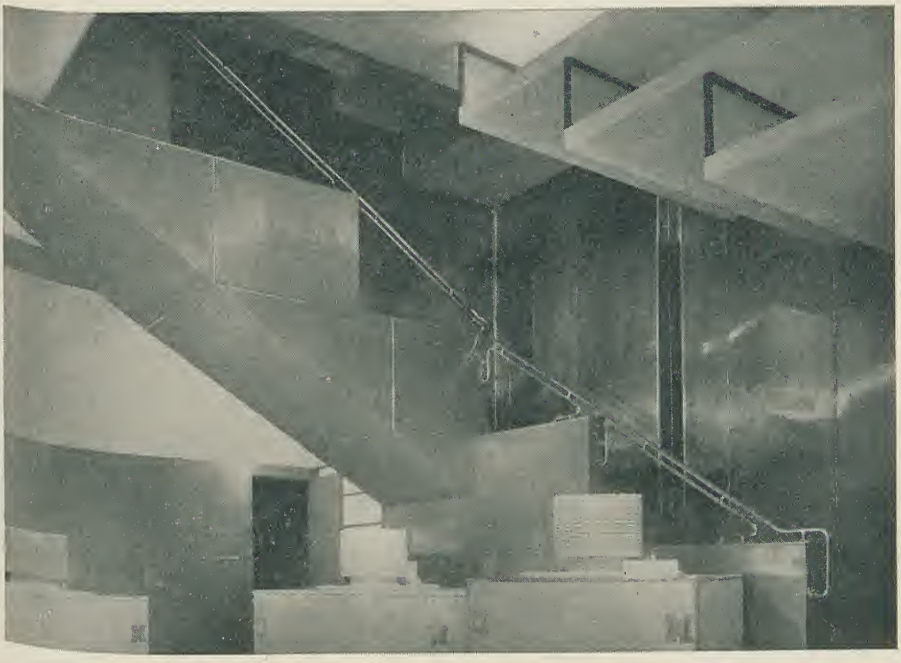


Fig. 1.—Metal-faced plywood in a showroom

BEFORE dealing with specific purposes for which plywood may be used, the following short notes with regard to methods of application and treatment may be given.

Protecting from Moisture

The edge of plywood should always be guarded and protected against moisture. This can be done by either fixing the edges in rails or fitting to the bottom end of the sheet a triangular strip so as to carry rain water or other humidity away from the edge.

Plywood is liable to absorb and discharge moisture in the same way as ordinary timber. For practical purposes, therefore, it is necessary to watch the moisture content of the plywood sheet before putting it to actual use. This does not imply that elaborate instruments need be used, but it is certainly advisable to make sure of the source from where

the plywood is obtained. Plywood boards that have been allowed to lie for a long time in damp warehouses will not give satisfactory service when subjected to paint work, polish, or varnish, or in regard to their flatness ; properly stored plywood, however, will be free from all these defects.

If there is any doubt as to the humidity content of a plywood sheet it is always advisable to keep it for a week or two in an atmosphere of fairly constant temperature and humidity. Once the plywood sheet is covered with paint, polish, or varnish, humidity will no longer affect the sheet, and distortion will therefore not arise.

This should also be borne in mind when fixing plywood to walls, floors, or ceilings, and direct contact between the plywood sheet and any moisture-carrying or producing agent should be avoided by providing an air space between walls, cement floors, or cement ceilings and the plywood sheet itself.

A Suitable Coating

To ensure satisfactory wear and moisture resistance plywood can be covered with a paraffin coating, which, in the case of very porous woods, should be applied twice or three times. This treatment will not interfere with paint, varnish or polish that may be subsequently applied.

Fire Resistance

Plywood, like ordinary timber, can be satisfactorily treated to ensure a certain degree of fire resistance, but, the process being rather complicated, the boards have for the purpose to be sent to factories specialising in this work. To avoid this, wherever fire resistance is essential, metal-faced plywood or asbestos-covered plywood can be effectively employed.

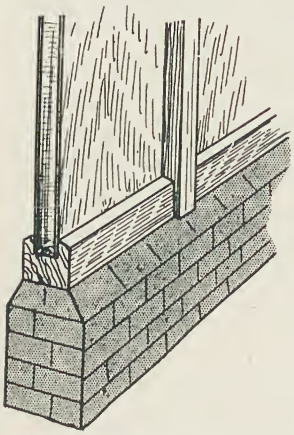


Fig. 2.—EXTERIOR WORK

Plywood panels fixed in grooved framework on brick foundation.

Avoiding Shrinkage

Plywood is subject to a certain amount of contraction and expansion under the influence of atmospheric moisture. Whilst this alteration of surface is very minute, it may be responsible for certain waviness unless a space of about $\frac{1}{8}$ in. is left between the boards when fixed on partitions next to each other.

Joints

Thin plywood under $\frac{1}{2}$-in. thickness can be joined together sideways only by means of a batten. Stouter boards, however, can be safely tongued and grooved and fitted together.

Corner joints, with thin plywood, also require a batten to work to, on either the inside or outside of the angle. Stout boards of ½-in. thickness and up can be tongued and grooved or treated similarly to any other sheet of wood.

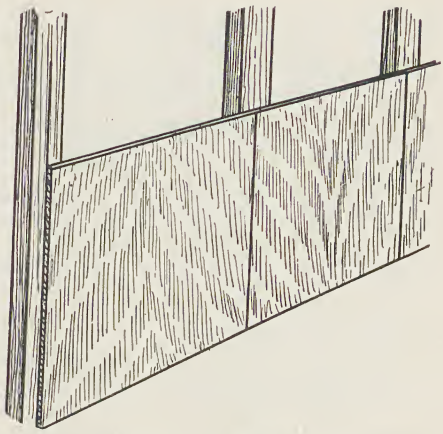


Fig. 3.—Fixing of simple plywood panelling

How to Bend Plywood

Bent corners can be more easily made with plywood than with ordinary wood. Thin sheets up to ¼ in. do not require steaming, but stouter boards must be steamed. Metal-faced plywood can be rolled to shape within reasonable limits like ordinary metal, whilst asbestos-covered plywood and plywood insulating boards with cork or wood pulp cores must be used flat.

Staining

For staining plywood, the surface at first must be carefully sanded, then brushed to remove the dust. It can thereupon be stained with excellent results, giving generally a more interesting pattern of the grain than can be obtained from staining ordinary wood panels consisting of several different pieces. Practically any stain can be employed with success, ranging from ordinary black japan, mixed with turpentine, to the finer stains such as Stainax and chemical stains.

Painting

For paint work, plywood must be carefully selected to save unnecessary labour and expense. Plywood made of hard woods will, under all circumstances, give a better painting surface and require less primer than the softer varieties.

EXTERIOR STRUCTURAL WORK—LIGHT BUILDINGS

Garden sheds, tool sheds, garages, and storage houses can be satisfactorily and cheaply erected with plywood, and in this respect it is perhaps difficult to find any other material which is so low in cost and at the same time is so simple to handle.

Foundation

These outside structures may be erected on a foundation of brickwork or concrete. The join between the foundation and the plywood walls or linings should then be well insulated so as to prevent any damp-

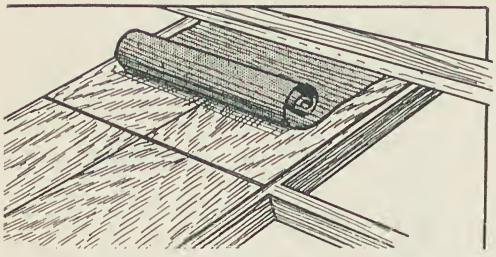


Fig. 4.—ROOF OF PLYWOOD SHEETS COVERED WITH ROOFING FELT

ness passing through the wall entering into the edges of the plywood sheet. This can be achieved by fitting the plywood sheet into a grooved timber frame or by covering the edge over with metal, roofing felt, or other suitable material. If such protection on the lower edge of the plywood sheet should prove difficult, a narrow rail may be fixed to the bottom end of the sheet to ensure that the water is kept away from the lower edge.

Plywood Panels

The building may be erected on a framework, then thin plywood, say $\frac{1}{4}$-in. thickness, can be used. If stout plywood is used, say $\frac{1}{2}$ in. or thicker, these panels may be tongued and grooved on the edges, not necessarily joined together with supports, always provided that the lower rail on the foundation, as also the top rail forming the rest for roof rafters, is sufficiently strong as to ensure the building being rigid.

Joints of Panels

The joints between the panels on the outside of the building should always be covered with strips so as to prevent wet and dampness penetrating into the panels.

Roof

The roof can be easily affixed by spacing rafters to meet the size of the sheets to be employed, and panels of about $\frac{3}{16}$-in. to $\frac{1}{4}$-in. thickness may be used for this purpose. The panels can be nailed or screwed to the rafters.

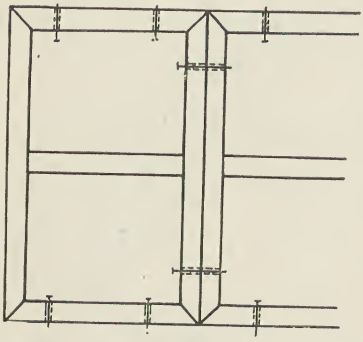


Fig. 5.—FOR PORTABLE BUILDINGS

Method of joining framework in sections.

If the roof is made of one plywood sheet, or of two sheets each covering fully one of the two sloping sides of the roof, the panels must be well paraffined and painted and need not necessarily be covered over with other roofing materials, but if the roof is made up of a number of panels, roofing material is strongly advised in preference to strips covering the joints.

Windows and Doors

Spaces for windows and doors can be provided for without great difficulty and

require no detailed description; doors can be satisfactorily built up on a framework of timber covered with a plywood sheet on each side.

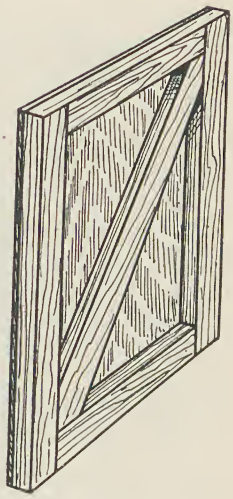


Fig. 6.—A PLYWOOD DOOR ON WOODEN FRAME

Plywood sheets are attached on both sides of frame.

Finishing Plywood Surfaces

All plywood on the outside of the building should be well oiled or varnished or painted, and in this respect be treated similarly to ordinary timber. If it is desired to stain the outside so as to show the grain of the timber, size should not be applied, but only varnish on top of the stain.

How to Build Metal-coated Plywood Buildings

Satisfactory work can be done with plywood coated with metal on the outside. This type of material can be strongly recommended for outbuildings which are intended for permanent use. Joints can effectively be made by allowing the metal sheet to overlap the plywood core, and screwing, nailing, or riveting the overlaps securely to the adjoining sheet.

Doors

Doors and bottom panels should also be provided with overlapping metal strips and these bent over the edges and secured on the inside of the panel, so as not to expose anywhere the wooden core to outside atmosphere.

Sizes of Panels

The following figures give the spans that may be allowed for structural and panelling work made of ordinary multi-ply boards. From this it will

Material	*Thickness*	*Span in Inches of Simple Beam to give Constant Deflection*	
		Cross-grained	*Long Grained*
Birch	4 mm. (bare $\frac{3}{16}$ in.)	16	34
Birch	5 mm. (full $\frac{3}{16}$ in.)	19	41
Birch	6 mm. ($\frac{1}{4}$ in.)	24	42
Birch	9 mm. ($\frac{3}{8}$ in.)	37	53
Birch	12·5 mm. ($\frac{1}{2}$ in.)	63	89
Birch	15 mm. ($\frac{5}{8}$ in.)	85	100
Alder	5 mm. (full $\frac{3}{16}$ in.)	14	29
Okoumé	5 mm. (full $\frac{3}{16}$ in.)	16	31

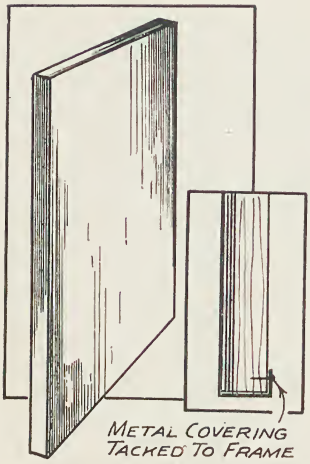


Fig. 7.—OUTSIDE PLYWOOD DOOR FACED WITH METAL ON ONE SIDE

be noticed that rafters and uprights can be spaced much wider when using plywood as compared with ordinary timber.

Metal-faced plywood and joinery boards allow, of course, for still wider spacing of supporting battens. In a general way, fairly stout plywood is recommended; this obviates the necessity of using too many supports and, therefore, facilitates building and lowers the cost.

PORTABLE BUILDINGS

Similar principles may be followed to those described above, but the measurements of the different panels should be so standardised as to make them convenient for handling during both erection and transport. A simpler way of constructing portable buildings, however, is to frame each panel separately and to bolt these frames together on erection.

Plywood Flooring and Roof

Flooring can be constructed from plywood in sections. The roofing joists should rest on four (or more) upright supports and be held in position by hooks or sockets. The roof should preferably be made of one piece, or if it is to be jointed it must be provided with strips to cover the joints.

INTERIOR STRUCTURAL WORK

Whilst plywood is very useful for outside work, it is still more valuable inside buildings.

Partitions and Walls

Ordinary partitions can be erected on a framework panelled both sides with comparatively thin plywood sheets ($\frac{3}{16}$ in. to $\frac{1}{4}$ in.).

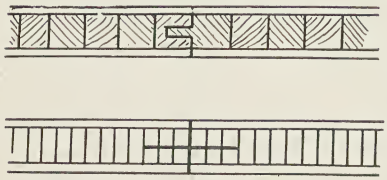


Fig. 8.—JOINTS BETWEEN TWO JOINERY BOARDS

Structural walls for dividing spaces are more suitably made of thicker plywood boards and joinery boards. For this purpose a framework must be erected, covered on both sides with plywood sheets, and the space

between filled with either sawdust, paper, or other sound-resisting material.

Ceilings

Ceilings can be satisfactorily made from plywood by nailing thin sheets of about $\frac{1}{8}$-in. to $\frac{3}{16}$-in. thickness direct to the joists and covering the joints with strips. The design need not necessarily follow ordinary square shapes, but may be made to suit individual taste in regard to period and style.

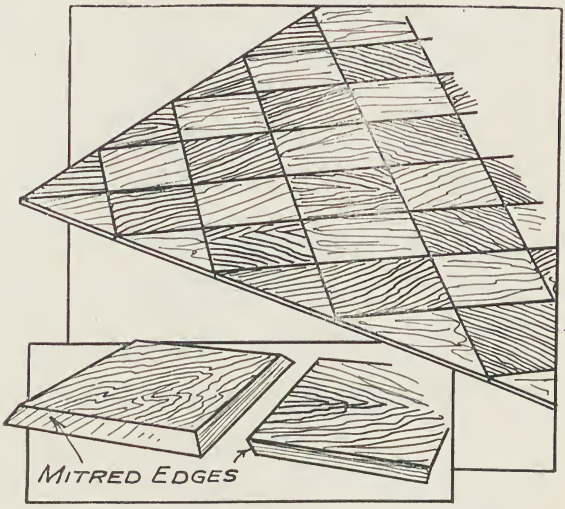


Fig. 9.—PLYWOOD FLOOR COVERING
Flooring squares are mitred as shown.

Floors

Floors can be satisfactorily laid direct on the joists by utilising plywood of $\frac{3}{8}$ in. or $\frac{1}{2}$ in. nailed to them. For this purpose large sheets can be used or smaller ones cut to square or other shapes. It depends upon the treatment of the floor as to whether these flooring boards are laid ordinarily or selected in regard to their grain to form a pattern. (See Fig. 9.)

PLYWOOD REPAIR WORK

In old houses plywood can be satisfactorily employed to remedy a great number of defects, the repairs of which would entail a great deal of expense and labour. Cracked ceilings and walls, mis-shaped floors, shrunk flooring boards, etc., can be satisfactorily repaired and restored to new appearance at small expense.

For these purposes plywood need not be employed in stout thicknesses, but sheets varying from $\frac{1}{8}$-in. to $\frac{3}{16}$-in. thickness will generally suffice.

Covering Walls

When covering walls it is essential, however, to observe the necessity of keeping the plywood covering away from any wall that may show, or be inclined to show, dampness. It is, therefore, to be recommended to affix battens of about $\frac{1}{4}$-in. thickness to the wall and to nail or screw the plywood panels on to these. In ordinary circumstances it will be

TYPES AND SIZE

MULTI-PL

WOOD.	THICKNESS.	CONSTRUCTION.	SIZE. *Length* with the grain.	SIZE. *Width* acros the grain.
Birch	3, 4, 4½, 5, 6 mm. 6, 8, 9, 10, 12½, 15, 18 mm.	3-ply 5, 7, 9 or 11-ply	24–84 in.	24–60 in.
Alder	3, 4, 5 mm. 6 mm. 8–18 mm.	3-ply 3 or 4-ply 5, 7, 9 or 11-ply	40–78 in.	24–60 in.
Okoumé (Gaboon)	3, 4, 5 mm. 6 mm. 8–18 mm., 21, 26, 30 mm.	3-ply 3 or 4-ply 5, 7, 9, 11, 13, 15-ply	39–120 in.	39–60 in.
Abachi	Ditto	Ditto	Ditto	Ditto
Pine	4½–6 mm. 9–30 mm.	3-ply 5–15-ply	60–120 in.	9–60 in.
Oak	4½–6 mm. 9, 10, 12½ mm.	3, 4, 5-ply 5, 7, 9-ply	48–72 in.	36–48 in.
Ash	4, 5, 6 mm.	3-ply	60–78 in.	24–48 in.
Hoop Pine	4½, 6 mm. 9 mm.	3-ply 5-ply	60–72 in.	36–48 in. 36–48 in.
French, Italian, Circassian, American Walnut	4, 4½, 5, 6 mm.	3, 4, 5-ply	48–72 in.	24–48 in.
Beech	4, 5, 6 mm. 8–30 mm., 38, 40 mm.	3-ply 5–15-ply	39–78 in.	24–60 in. 24–48 in.
Poplar	4, 5, 6 mm.	3-ply	24–78 in.	24–60 in.
Cottonwood	⅛, 5/16, ¼, ⅜ in.	3-ply	60–84 in.	24–60 in.
Mahogany (Sapeli, Honduras)	4, 5, 6 mm.	3, 4, 5-ply	24–78 in.	24–60 in.
Sycamore	4½, 6, 9 mm.	3 or 5-ply	24–120 in.	24–48 in.
Hickory, Bird's-eye Maple, Maple, Gum, Hazel, Pine, Tupelo	4½, 6, 9 mm.	3, 4, 5-ply	48–72 in.	

JOINERY

WOOD.	THICKNESS.	CONSTRUCTION.	CORE.	SI *Length* with the grain.
Birch	⅜–2 in.	3-ply. 5-ply.	1-in. Sawn Birch blocks. 1-in. Sawn Birch blocks.	60 in. 60 in.
Alder	⅜–2 in.	3-ply. 5-ply.	1 or ½ or ¼ in. Sawn Pine blocks.	50–60 in.
Okoumé (Gaboon)	⅜–2 in.	3-ply. 3-ply. 5-ply. 5-ply.	1 or ½ in. Sawn Okoumé or Pine blocks. ⅛ or ¼ in. Laminated veneer. 1 or ½ in. Sawn Okoumé or Pine blocks. ⅛ or ¼ in. Laminated veneer.	

METAL-FACED

	3/16–½ in.	Faced one or both sides.	Birch, Okoumé, or Alder.	72 in.

ASBESTOS-FACED

	6–26 mm.	One or both sides.	Okoumé.	39–78 in.

CORK-LINED

	9 mm.–2 in.	4 mm. Okoumé, Birch or Alder outside.	Cork slabs.	24–96 in.

PULP CORE

	12½ mm.	4 mm. Okoumé plywood outside.	Wood pulp.	72–96 in.

OF PLYWOOD

BOARDS

MANUFACTURE.	COLOUR.	SURFACE.	USE.	FINISH.
English, Canadian, Esthonian, Finnish, Russian, Latvian, Polish, U.S.A., Lithuanian.	White to yellow.	Hard, smooth grained.	Panelling, structural, veneering base.	Stains, polishes, and paints well.
Russian, Polish, Austrian, Hungarian.	Yellow to light brown.	Slightly porous, smooth grained.	Concealed work.	Stains. Requires primer for paint.
English, French, German, Dutch, Spanish, Norwegian.	Pink.	Porous, smooth grained.	Panelling, structural, veneering base.	Stains well.
German, French, Spanish, Belgian.	Light yellow.	—	Panelling, veneering base.	Stains and polishes well.
Canadian, American, Swedish, Norwegian, German, Latvian, Polish.	Yellow.	Pronounced year rings.	Panelling, structural.	Stains and paints well.
English, Japanese, Finnish, German, Polish, U.S.A., Dutch, French, Belgian, Austrian, Yugo-Slavian, Latvian.	Brown.	Hard, but wide grained.	Ditto.	Stains and polishes well.
Polish, Lithuanian, Siberian, Japanese.	Brown.	Hard, flat, but wide grained.	Ditto.	Ditto.
Australian.	Yellow to light brown.	Semi-hard, smooth grained.	Panelling, veneering base.	Stains and paints well.
English, German, U.S.A., French, Belgian, Italian.	Brown to black.	Hard, smooth grained.	Ditto.	Polishes well.
German, Polish, Austrian, Hungarian, Roumanian.	Yellow to red.	Ditto.	Panelling, structural.	Stains, polishes, and paints well.
Dutch, Belgian, French.	White.	Porous, hairy.	Concealed work.	—
Canadian.	White.	Porous, very faint grain.	Panelling.	Stains well.
English, French, Italian.	Brown to red.	—	Panelling.	—
U.S.A., English.	White to yellow.	Hard, smooth grained.	Panelling, structural, veneering base.	—
	—	—	Panelling.	—

BOARDS

Width across the grain.	MANUFACTURE.	SURFACE.	USE.	FINISH.
84 in.	Finnish.	Hard, smooth grained, jointed.	Structural work, veneering base.	Stains, polishes, and paints well.
144 in.	Lithuanian, Polish, German, Swedish.	Slightly porous, smooth grained, jointed.	Ditto.	Stains.
60–177 in.	English, Lithuanian, German, French, Belgian, Austrian, Italian, Dutch, Danish.	Porous, smooth grained.	Ditto.	Stains well.

BOARDS

36–48 in.	English, German, U.S.A.	—	Structural.	Galvanised Steel, Black Sheet Iron, Aluminium, Stainless Steel, Brass, Copper, Zinc, Monel Metal.

BOARDS

39 in.	German.	—	Structural.	—

BOARDS

36–60 in.	English, German.	—	Structural.	—

BOARDS

36–48 in.	French, German.	—	Structural.	—

frequently found that a batten of the thickness of the existing skirting board will meet the purpose, and this will enable the joiner to bring his plywood panelling flush to the floor, whereupon a fresh skirting may be provided at the bottom, whilst part of the old picture rail can be left exposed to finish the panelling at the top.

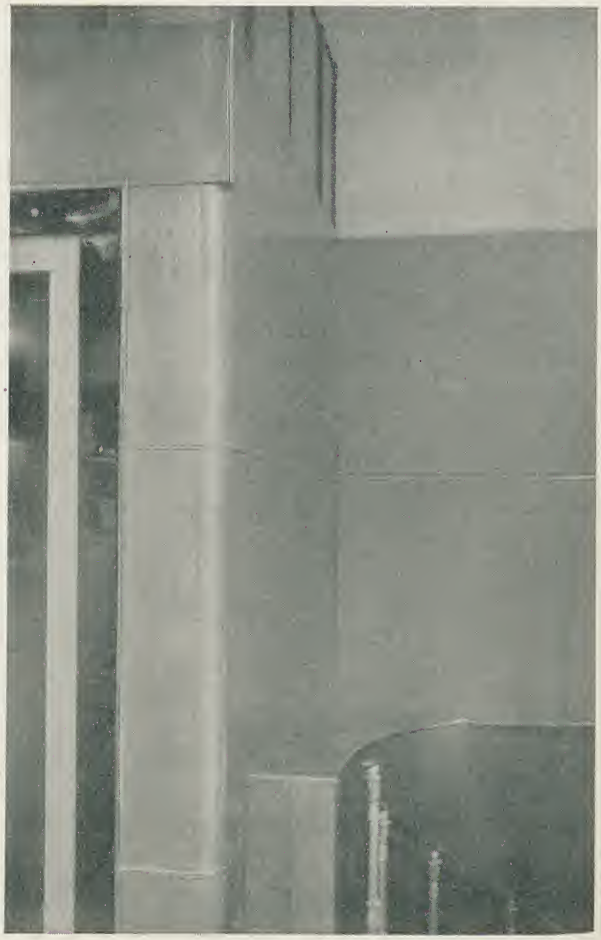


Fig. 10.—METAL-FACED PLYWOOD USED FOR INTERIOR DECORATION

Repairing Floors

In regard to the repair of old unsatisfactory floors, it is advisable to utilise small sheets of plywood in the size of about 6 in. to 9 in. square, as otherwise it will be difficult to follow those irregularities in level from which old floors are suffering, either through wear of the boards or the settling of the building. These small panels can be packed from the bottom so as to lie perfectly level, but if this entails too much work no great harm will be done by following the unevenness of the floor, as the size of the boards is sufficiently small to ensure satisfactory joints between the flooring squares. This method of floor repair compares favourably in cost with lino and produces a much more satisfactory job, especially if the flooring squares are laid to pattern in accordance with the grain which they show.

The gaps between the floorboards may be filled in with either putty or sawdust and glue and the plywood may have square edges ; alternatively, the edges can be mitred at an angle of, say, 45 degrees, which will then allow

for adjustment as may be necessary to ensure a smooth surface free from gaps.

Kind of Wood Required for Flooring

When selecting squares for flooring, attention should be paid to the type of wood, and in this connection birch and ash are preferable because they withstand wear better than other woods, and it is also to be recommended that plywood with a minimum thickness of $\frac{1}{16}$ in. outside veneer be selected. (Veneered panels should not be used for this purpose.)

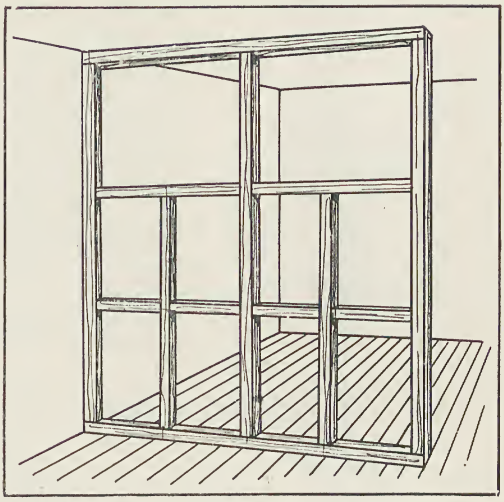


Fig. 11.—Framework for panelling

Finishing Plywood Floors

These floors can be either painted, varnished, or stained naturally. A simple stain of black japan mixed with turpentine, to suit the shade required, will be found quite satisfactory and yield an excellent surface for polishing and Ronuking.

Wear

Without going into unnecessary details, it may be stated here that owing to the construction of the wood all friction and wear is met on all sections of the floor with the same resistance, i.e. the strongest fibre of the wood takes the brunt of the wear. This is not the case in ordinary wood floors, which are not true sections of the round tree; this accounts for ordinary floors frequently wearing badly unless they are made of truly " quartered " timber.

FOR ODD JOBS

Plywood can be utilised by the builder both in and out of the house for numerous purposes which are conveniently described as odd jobs, both of a purely practical and of a decorative nature. It is impossible to enumerate all these, but one may briefly mention the advan-

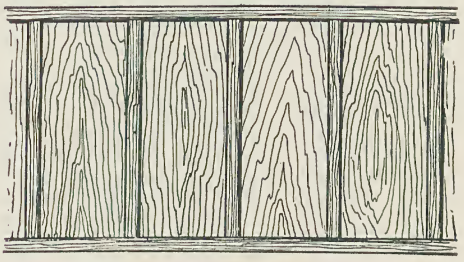


Fig. 12.—Simple panelling with small boards

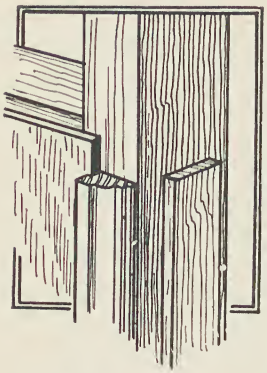


Fig. 13.—TREATMENT OF DOORPOST

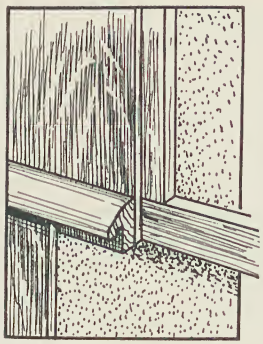


Fig. 14.—CHAIR RAIL WITH RECESS FOR LOWER PANEL

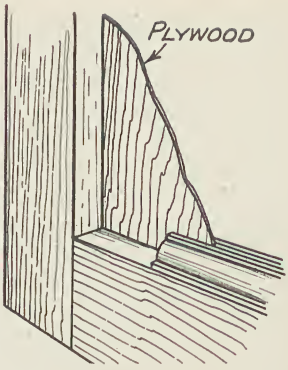


Fig. 15.—METHOD OF FIXING PANELS IN SIMPLE PARTITION

tages which plywood affords in erecting corner cupboards, linings of stair cupboards, linings of the loft—both on the floor and under the rafters—shelves, etc.

Tools Required

The tools required for working plywood and thin multi-ply are few, and may be shortly summarised as follows : a fine saw, a long plane, a gimlet, screwdriver, and a hammer, with sandpaper to smooth over the saw-cut edges. When dealing with joinery boards a larger saw may be required, and breast brace ; for handling metal-faced plywood a punch for making holes in the metal surface will be found useful. (Metal plywood should always be punched with the metal surface lying uppermost and driving the punch into the metal.)

WORKING DECORATIVE PLYWOOD

In regard to decorative schemes, the principles of workmanship are exactly the same as with ordinary plywood, but it is advisable on the whole, when dealing with expensive panels such as walnut, oak, mahogany, to procure the necessary plywood sheets in the required sizes so as to save unnecessary waste. These sheets can be obtained without difficulty, already prepared and veneered, from a number of manufacturers in the country. The average joiner, whether amateur or professional, seldom has at his disposal the necessary equipment to lay these veneers and press them satisfactorily to the plywood core.

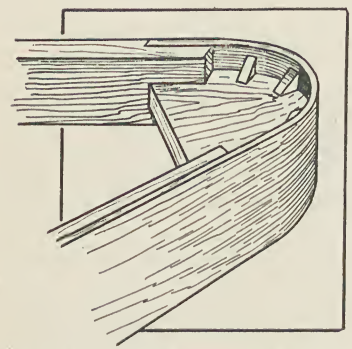


Fig. 16.—TREATMENT OF PLYWOOD AT BOTTOM OF STAIRCASE

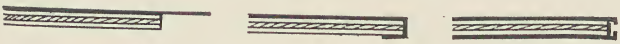


Fig. 17.—TREATMENT OF EDGES OF METAL-FACED PLYWOOD

Fig. 18.—FLAT JOINT FOR METAL-FACED PLYWOOD

Fig. 19.—COUNTERSUNK SCREW IN METAL-FACED PLYWOOD

Fig. 20.—REINFORCED FLAT JOINT FOR METAL-FACED PLYWOOD

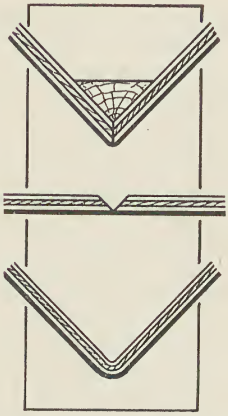


Fig. 21.—TREATMENT OF CORNERS WITH METAL-FACED PLYWOOD

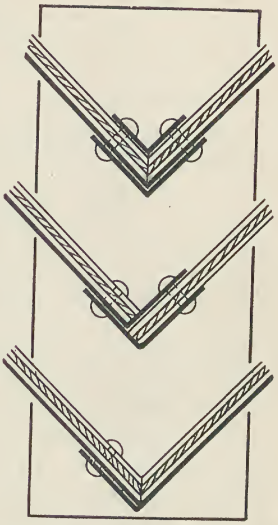


Fig. 22.—TREATMENT OF CORNERS WITH METAL-FACED PLYWOOD

Hiding Edges of Joinery Boards

When dealing with more elaborate panel work the difficulty always arises of hiding the somewhat unsightly edge of the plywood board. With thin plywood this can be best achieved by allowing these edges to fall into grooves or by working flush to the supporting battens and covering the corners with beadings.

The difficulty is, however, increased when dealing with joinery boards, and especially when these reach the edge of a panelling or form a corner in themselves, thus exposing their edge. This edge may be anything from ½ in. to 2 in. wide. In order to hide this edge either the edge may be planed down smoothly and veneered with a veneer matching the rest of the panelling or work, or a solid wood edge may be affixed to it by simply gluing it flat on to the joinery board edge or by affixing a solid strip with a tongued and grooved glue joint.

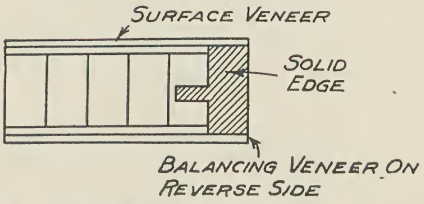


Fig. 23.—FLUSH DOOR WITH VENEER

The joinery board is surrounded on all four edges with a solid edge, as shown.

RUNNING AND MAINTENANCE OF CONCRETE MIXERS

THERE are two ways of looking at a concrete mixer. It may be regarded as a necessary nuisance, capable of turning out concrete at a less cost than by hand, or it may be regarded as a means of making that extra profit which is useful in offsetting the too frequent losses caused by bad luck on so many building jobs.

Even badly handled, a mixer will turn out concrete at two shillings a cubic yard as against six shillings by hand, but properly handled it will do the same amount of work for tenpence. The obtaining of one or other of these two costs is largely in the hands of the foreman, and with a little attention to detail the lower figure is readily achieved.

Importance of a Good Driver

Having requisitioned a mixer from the plant yard, choosing a size in proportion to the amount of concrete in the job, the next step is to obtain a driver. As modern machines are designed to be run by unskilled or semi-skilled labour, this is not a difficult matter, as the extra penny an hour usually paid results in plenty of volunteers; but it is important to pick a man who is quick in his movements and tidy in his person.

In addition to the extra pay, he should be given half an hour every night, after knocking-off time, to clean and lubricate his charge, and it should be explained to him that this time is to allow him to have the machine actually running as soon as the whistle blows in the morning.

If he has handled mixers before he will have some idea as to what he wants in the way of tools and materials, but if not the following should be ordered to be sent with the mixer.

Tools Required

A good-quality box spanner to fit the sparking-plug of the engine, as any other form of spanner always results in broken insulations; good-quality open-ended spanners covering $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$ Whitworth nuts; a pair of electricians' pliers, a spare new sparking-plug in its original box, a wooden-handled screwdriver, a gallon can of paraffin oil, a half-gallon can of lubricating oil, an oil-feeder, 7 lb. of yellow cup grease, a grease gun, a small tin funnel about 6 in. across, a smaller one about 3 in. across for filling the carburettor chamber, a bundle of old

rags (which are better than cotton waste and not so likely to have frayed ends to catch on split pins or moving parts), and a clean new builders' pail about 60-lb. size.

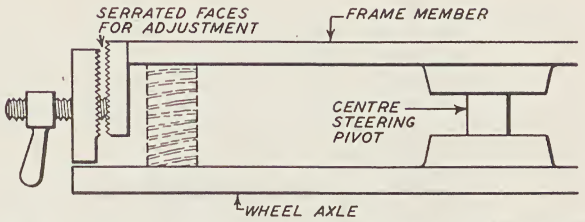


Fig. 1.—TYPICAL JACK FOR MAKING MIXER FRAME SOLID WHEN LEVELLING UP

If the serrations are clogged with dirt or concrete and will not grip, drive in a wooden wedge as shown by dotted lines.

The whole of this kit can be supplied in a box fitted with a lid and padlock, the foreman having a duplicate key in case of illness of the driver.

Placing the Machine

The next point to consider is the placing of the machine, and considerable care should be given to this matter, as it has the greatest effect on the cost of placing the concrete. There is always a temptation to dump the mixer anywhere as long as it is close to the road, but although sleeper track costs money to lay it is far cheaper than lengthy barrow runs.

If there is much concrete on upper floors a hoist will be required, and the mixer should be placed as close to this as is practicable, with a firmly laid platform of deals covering the loading side of the machine, and of such area as will allow of storage of ballast in case of breakdown in supplies. The ideal is to have ballast delivered as fast as it is used, so that it can be tipped close to the loading hopper of the mixer, to avoid the need for trimming.

Preparing the Mixer for Work

As soon as the mixer arrives on the job it should be wiped over with paraffin oil, particularly on the outside of the drum and the frame on the loading side. This will prevent the sticking of splashed concrete.

Importance of Correct Levelling

It should then be carefully levelled in all directions, and this part of the work should be checked by the foreman himself, as no other detail can cause so much trouble. The normal mixer of the closed-drum type has four rollers supporting the mixing drum, and if these are out of level the drum will inevitably run over to one side, wear the rollers unevenly, allow the main drum chain to ride up the sprockets, and cause wear and eventual cutting of the discharge mouth of loading hopper by

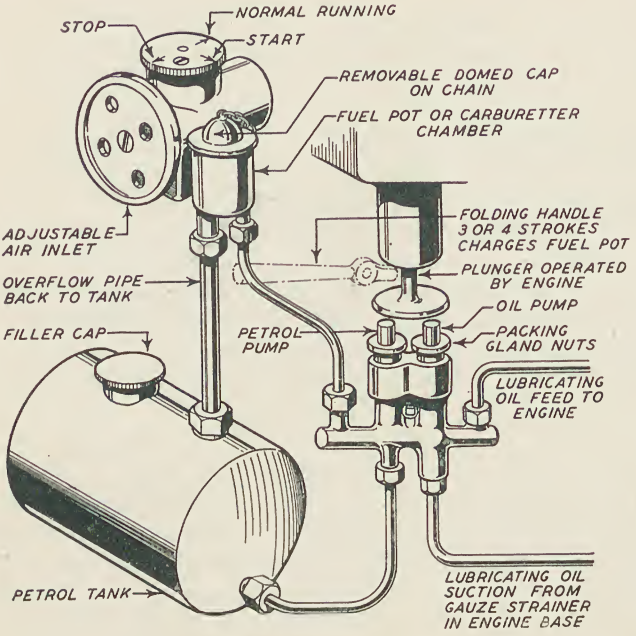


Fig. 2.—FUEL AND LUBRICATING OIL FEED SYSTEMS ON THE LISTER HOPPER-COOLED (FOUR-STROKE) ENGINE

forcing the drum opening against it.

If the Machine Is Fitted with a Central-pivoted Front Axle

In machines fitted with a central-pivoted front axle, care should be taken that use is made of the jacks supplied on the front end of the frame, and if they are out of order through rust or dried cement caking the threads, a wooden wedge should be driven between frame and axle.

An Important Point

If the mixer has been delivered on a lorry it will probably have had the loading hopper detached so as to take up less room in transit. Before reassembling examine the discharge lip, and if it is dented or burred file it smooth, as nothing interferes so much with fast running, and it is more easily got at than when in position on the mixer.

Check all the grease-gun terminals to make sure they have been charged, test the drum-driving chain for slackness, and also the smaller engine-drive chain, and then examine the engine.

Examining the Engine

The Lister, which is commonly fitted to mixers, carries an instruction booklet in a tube on the front of the crankcase, but as it is more often than not missing, common sense must be the guide in locating the lubricating oil filling-plug on the crankcase. See that there is a good level of oil; dip the petrol tank and fill if necessary, and then oil all moving parts with as few drops as possible, paying most attention to the control rods connecting the governor and the throttle.

Whether radiator or hopper cooled, see that there is plenty of water; make sure the cylinder drain-cock works freely.

Starting

Most mixer engines now run on petrol or paraffin, but in both cases are started on petrol. The Petter two-stroke engines have a diaphragm pump built in the side of the crankcase, the pulsations of the diaphragm being caused by the alternate pressure and vacuum in the crankcase as the piston moves up and down. It is necessary to pour petrol into the carburettor chamber before starting. With the Lister engine, fuel is fed from one plunger of a two-plunger pump provided with a hinged handle. Two or three strokes on this handle will force up enough fuel for a start, after which the action is automatic.

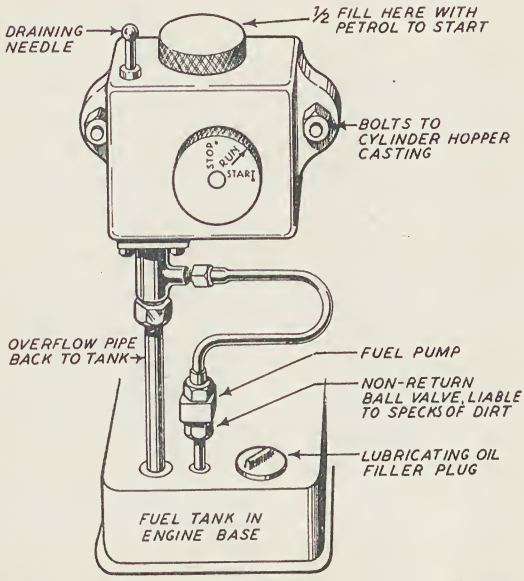


Fig. 3.—FUEL SUPPLY SYSTEM IN THE PETTER TWO-STROKE HOPPER-COOLED ENGINE

This engine starts on petrol and runs on petrol, paraffin, or "Shell Spark."

If the engine has been standing for some time out of use it is well to pour some lubricating oil around the packing-gland of the plunger, as leaks at this point will prevent proper working.

By removing the domed cap on the carburettor it is easy to see whether the pump is in order.

Much futile swinging of the starting-handle can be saved by taking out the sparking-plug and testing the ignition by laying the plug on the cylinder head. A slight turn of the flywheel should be sufficient to give a good spark.

In Cold Weather

On both Petter and Lister engines the large-headed screw controlling the fuel flow is marked with two arrows indicating the running and starting positions, the latter giving a fuller fuel opening than the former. Having replaced the plug, make sure the high-tension lead is on, set the fuel screw, and swing the engine sharply, when it should immediately fire. If the weather is cold and the engine stubborn, a small doping of

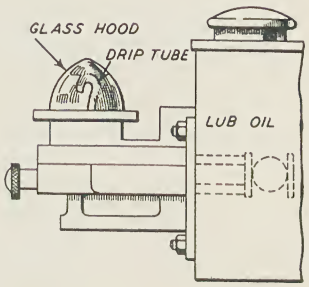


Fig. 4.—PETTER SIGHT-FEED LUBRICATOR FED BY TWO-PLUNGER PUMP IN TANK

petrol through the plug may help, whilst dipping the plug in petrol and lighting with a match to warm it up, and the use of hot water in the radiator or hopper, are helpful.

Trouble Due to Incorrect Timing

No mixer should be sent to a job unless it has been tested, but if it has been sent out in a hurry there may be trouble due to slipping of the timing.

This will not cause absence of spark at the plug but it will give the spark at the wrong time, and it can be checked by setting the engine so that the crankshaft is at top dead centre (which can be seen by having the flywheel keyway uppermost) and then removing the cover from the make-and-break of the magneto. If the points are seen to open when the wheel is rocked back and forth it is unlikely that the fault lies here. If there is a spark at some other point in the revolution of the flywheel, the magneto must be retimed.

With Petter two-strokes started on petrol but run on paraffin, even a few turns of the crankshaft will pump paraffin into the fuel pot, thus diluting the starting-petrol, and it must be drained out by lifting the spring-pressed needle valve alongside the control screw, and a fresh charge of petrol introduced.

The likeliest cause of trouble is a bad plug, which may fire in the open but fail under compression in the cylinder. The remedy is to clean it or use the spare new plug, sending the bad one back for renewal.

The Clutch

When the engine is running satisfactorily, the clutch which engages the drum drive should be tested. Some emergency may call for stopping of the drum in a hurry, and these clutches too often refuse to function. As the engine can be started with the drum in drive no one seems to bother about declutching, but it is a point which deserves attention, for if the engine breaks down whilst a mix is in the drum the latter can be turned round by hand to discharge the contents, whereas if the clutch is stuck the chain drive has to be dismantled.

With the drum turning, check its position on the track rollers. If it does not run central, check the levelling and get it correct before going any further.

The Hopper Loader Gear

Next try the hopper loader gear. Let the clutch in gently and run the hopper up and down two or three times, thus also testing the lowering brake. If fitted with automatic knock-out gear, try this out by pulling the clutch lever over to the raising position, and stand away. If it fails the wires will probably snap, but it is better to find this out with an empty hopper when you are ready for it than with a full one when you may be standing under it.

Coating a New Drum with Cement

Fill the water tank by hose or hand and try the water discharge, emptying the drum through the discharge chute on the other side. If satisfied with the tests the drum can be given a few shovels of cement to coat it if it is at work for the first time, as the small nooks and crannies will otherwise rob the first batch of cement and weaken it.

Loading the Hopper

In loading the hopper make it an invariable rule not to exceed the correct load. If it is a 7/5 mixer do not go above 7 cu. ft. of materials, if a 10/7 do not exceed 10, and so on. There is nothing to be gained by overloading, and everything to lose. When the hopper is raised it will strain the whole frame of the machine, stretch the wire ropes, damage the clutch, and bend the loading-hopper frame. When at the top of its lift the hopper will spill a lot of its contents on to the machine instead of into the drum, and if the overload gets safely inside the latter it will be splashed out before it is discharged from the chute.

Capacity of a 7/5 Mixer

Properly used a 7/5 will give 50 to 60 cu. yd. of concrete in eight hours. If the job requires more it should have a second or a larger machine. Overloading can easily cost £30 in repairs and a loss of anything up to a week whilst the parts are being replaced, so is on every count a losing proposition.

The Correct Way to Load

The most convenient method of loading is to have two men, one being given the extra job of loading the cement. Ballast should be shovelled in so as to slope against the sides and bottom of the hopper, the cement poured in or the bag broken if it is a one-bag mix, the heap being left undisturbed whilst filling is completed with ballast. When the hopper is raised the sandwich of ballast and cement will slide freely into the drum, whereas if the cement be placed in last the ballast will run first, leaving the cement to stick to the sides and lip of the hopper.

Under no circumstances should the under side need hammering to obtain a full and complete discharge. If it does, either the hopper is not being allowed to rise high enough, or the lip is dirty or rough.

Adding the Water

Some mixers have a synchronised water control which allows the mixing water to enter at the correct moment, but in machines not so fitted care should be taken that the bulk of the water is added to the drum as the mix starts to enter the drum, or the inclined paddles will carry some of it through the drum to the chute side so that the earlier

part of the mix will be very wet and the latter part dry. About 1 gal. should be allowed in before the mix, so as to wet the drum.

Output

Output of machines is based usually on ten-second loading and one-minute mixing at twenty revolutions of the drum, but the new ideas on dry mixing will probably result in the need for longer periods—up to two minutes per batch. Complete discharge should take about ten seconds, but if into wheelbarrows will of course depend on the quickness of the barrow men. They will be assisted by the use of pneumatic-tyred wheels, broad running-planks, and a wide, planked space for manœuvring up to the chute.

The engine will give its own warnings of incipient trouble: misfiring, steaming of the hopper or radiator, reluctance to lift the hopper load, should all be attended to at the earliest opportunity; but other failures can only be detected by examination when the machine is stationary. It is a good plan to feel all bearings after each four hours of running, and to take prompt steps to force more lubricant into any that are unduly warm.

This sort of attention becomes an acquired habit, need take only a few moments, and is well worth doing.

Cleaning the Mixer after Use

At the conclusion of the day's work the interior of the drum should be cleaned by loading a couple of cubic feet of ballast and water into the drum, allowing it to turn around for several minutes before discharging it. The hopper should then be brushed out and the lip carefully cleaned so that there is no trace of cement to spoil its surface. Once pitted the hopper is spoiled.

Drain the Cooling Hopper Once a Week

Although not necessary in warm weather, it is advisable to drain the cooling hopper once a week to prevent the caking of lime or sand deposits in the cylinder-head passages or the drain-cock. Should there be a stoppage, it is a pity to leave it until a frosty night results in a cracked cylinder. Poking with a bent wire usually clears the trouble, but in obstinate cases the water should be syphoned off with a short length of hose and a pint of spirits of salt poured in and left for, say, half an hour. Its action can be watched, and when it stops effervescing more acid should be added until the wire finally gets through. The acid should then be well washed out before refilling.

Maintenance Notes

At least once a week the engine crankcase should be drained of oil, the wire-gauze filter removed and cleaned, and new oil filled in to the correct level.

Valve guides should be oiled daily, also tappets and governor parts; the engine thoroughly cleaned, and the petrol tank refilled ready for starting.

Despite salesmen's optimism, all mixers require new parts at regular intervals, and a reasonable expenditure on spares and thorough overhauling will do much to lengthen the life of the machine.

A 7/5 should cost about £15 a year spread over a life of five years, after which, unless very lightly used, it will be best to scrap it.

Testing Chains

Chains should be tested for wear by laying them out on the ground in a straight line with all links pushed up together, and then pulled as far apart as possible, when the small stretch in each link will be magnified sufficiently to be easily measured.

As the largest drum chains cost only a matter of £3 it is false economy to run them stretched, as they are apt to mount the sprockets and seriously strain the countershaft bearings, besides jamming the drum into the main frame and bending the latter.

Track-wheel bearings can be tested by prying the drum off the rollers with a putlog, and should be replaced at the least sign of shake.

The tracks or tyres on the drums sometimes wear into a series of flats, but though they can be renewed it is an expensive job and better avoided except in emergency.

Discharge chutes need renewing at intervals, and it is quite possible that a new loading hopper will be needed once in the life of the mixer.

Engine Overhaul

Engine overhaul should include obvious replacements, careful scraping-in of big ends, and testing of the compression pressure which, whilst it can be kept up by fitting of over-size rings, will at last become incurable except by fitting of a new cylinder.

Some makers have an exchange service by which worn cylinders can be replaced by rebored ones, but it makes the fitting of new rings a difficult matter when wear takes place again.

Every mixer should be given a number and an account kept of all expenditure on parts, mechanic's time for overhaul, etc., and, if possible, a record of its output. When a machine is returned in bad condition from a job, part of the cost of overhaul should be charged to the job for the good of the foreman's soul, but the machine must not be expected to run for ever, and it is better to start with the assumption that it will be written off in five years and have had about 50 per cent. of its prime cost spent on it than to run it to death and be disappointed.

Whilst makers' claims of output costs of mixers are necessarily optimistic, there is no reason why users should not approach them very closely and so get the greatest value from one of the builders' most useful tools.

BRICKS USED IN MODERN BUILDING

TO secure the best results in any building, it is necessary that the proper materials shall be used in the most appropriate position, and that due consideration shall be given to the quality and suitability of the materials to the job which is expected of them. This applies in no small manner to bricks, and to meet the requirements of architects, bricks of varying qualities as to strength, colour, and texture are made, and are known by names which are appropriate to the use for which they are intended.

Engineering Bricks

Engineering bricks are the hardest and heaviest bricks used in this country. They are used where strength rather than appearance is required, but it should be noted that this does not imply that structures constructed entirely of this material are ugly, for when built in English bond with good mortar (usually cement mortar), very pleasing results are obtained, together with the requirement of stability which is always associated with such works as railway abutments and arches, dock walls, dams, sewers, etc. They are immune from attack by weather, and are practically indestructible under normal conditions, and the maintenance required is nil. Engineering bricks are also very effective when used for damp-proof course work.

Stock Bricks

Stock bricks is the term used most generally for the common bricks which constitute the major output of most brickyards. They are chiefly used in the building of dwelling-houses, interior work, backings to facings, and casings to steelwork.

Concrete Bricks

Concrete bricks are usually a substitute for the stock brick, but some manufacturers have a concrete facing brick on the market.

Facing Bricks

Facing bricks include any type of brick combining pleasing appearance and colour with good resistance to exposure to the vagaries of the weather, and are used for external walls.

Colours and Texture of Facing Bricks

They are now made in a variety of colours and textures, and are known by the makers' descriptions, such as silver-greys, flared red, rustic,

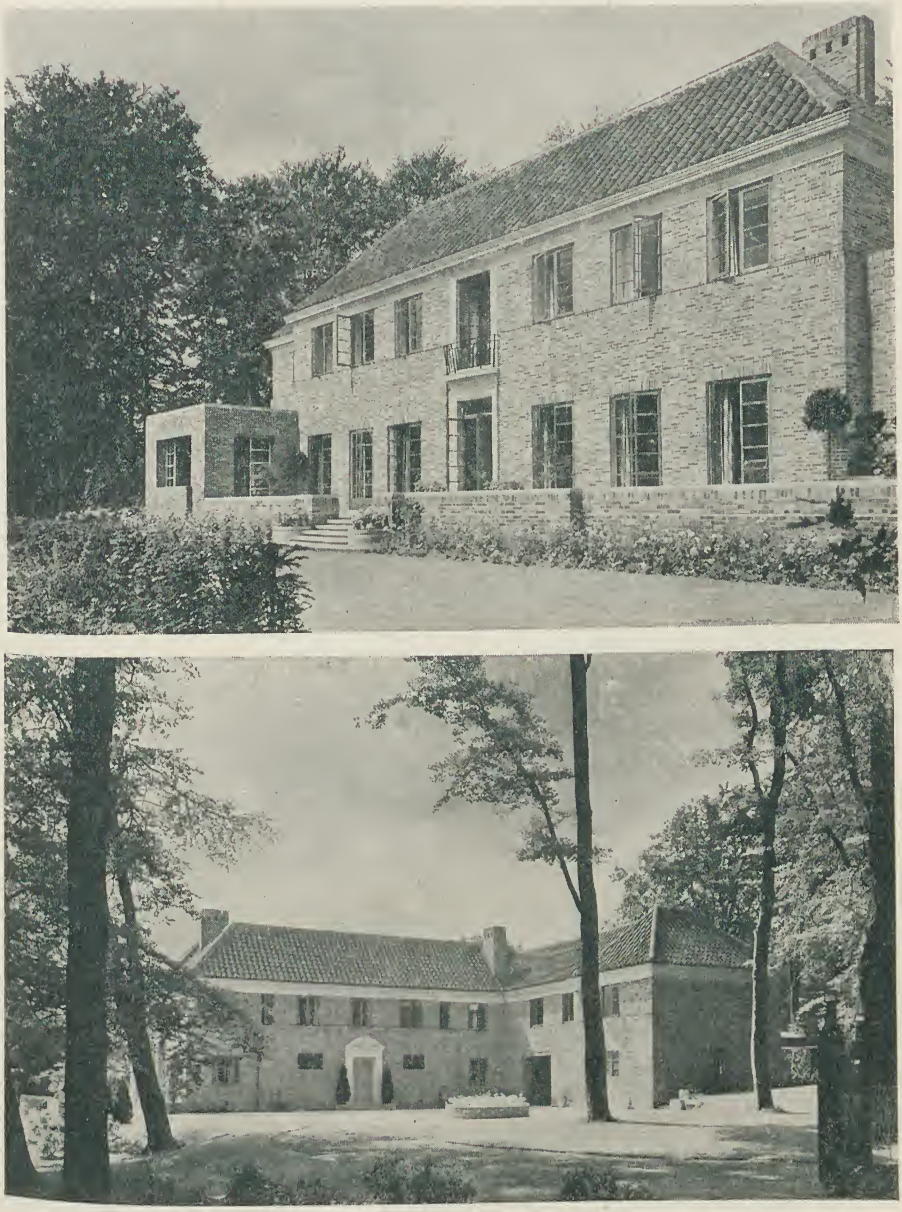
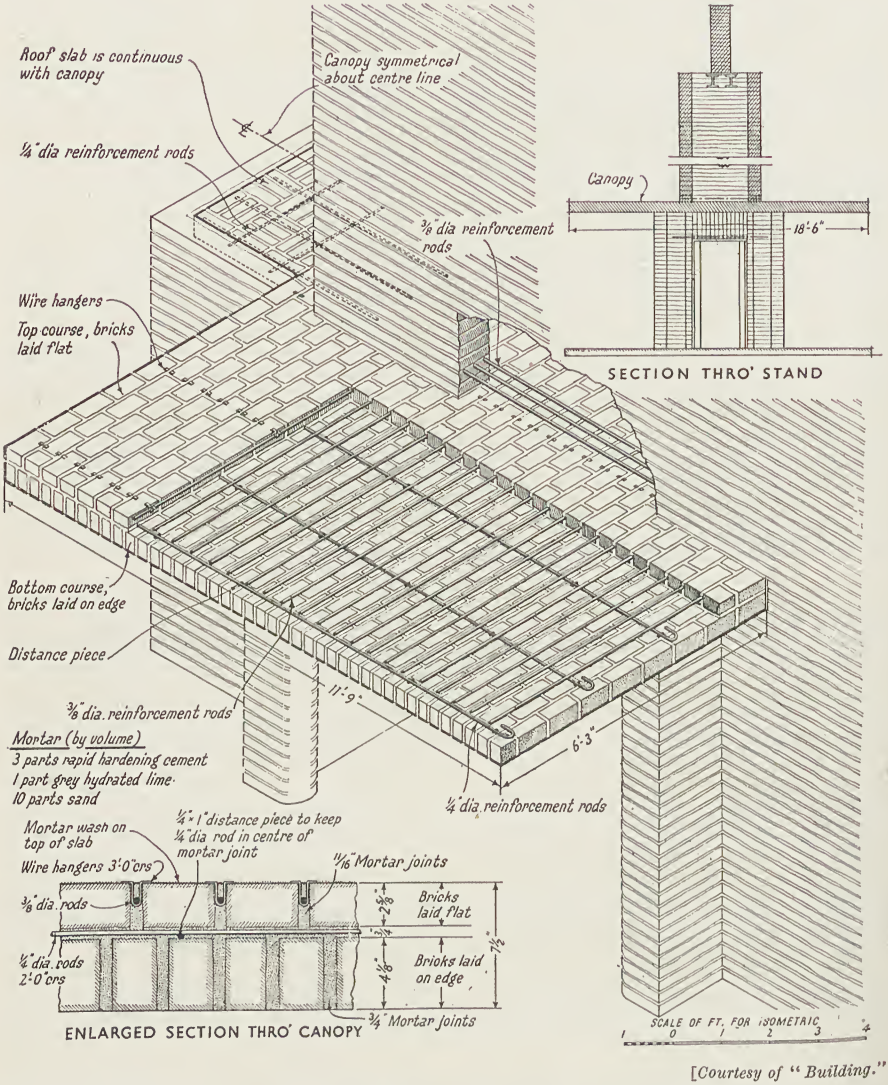


Fig. 1.—A MODERN COUNTRY HOUSE—THE KING'S HOUSE AT BURHILL

Top picture shows the south front, along which are the principal rooms. Constructed of Fletton brickwork in cement mortar, faced with thin hand-made sand-faced grey-brown multi-coloured bricks. Hard stocks used below slate damp-course. Stone dressings and main cornice, Portland stone. Roof covering, Lombardic tiling and half-round ridge and hips. (*Architect : C. Beresford Marshall, F.R.I.B.A.*)



[Courtesy of "Building."

Fig. 1A.—REINFORCED BRICE CANOPY

An exhibition stand by the London Brick Co. Ltd., demonstrating the use of reinforced brickwork.

sun-stone, sand-faced, ripple-faced, multi-greys, rugged mountain grey, mottled, etc., as well as the smooth-faced machine-made facings usually described as reds and buffs.

The smooth-faced bricks may be used with considerable advantage in buildings of the industrial type, such as factories, warehouses, etc. The rustic, sand-faced, and similar types of brick may be considered best suited to domestic buildings, if correctly designed, and due consideration be given to brick sizes for openings and piers. These give very pleasant results with English, Flemish, or other familiar bonds.

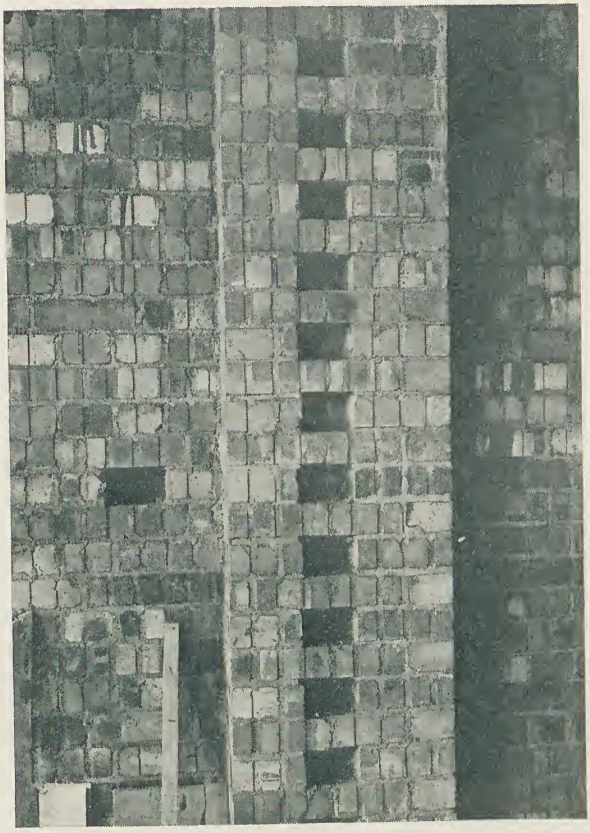


Fig. 2.—WALL OF FLETTON SLOTTED BRICKS

Bricks are keyed on one stretcher face and one header face, and are so made to ensure efficient adhesion of plaster (or stucco). Notice brick surround to stanchion, with 4½-in. toothing for division wall.

Glass Bricks

These are described on page 161.

London Stock Bricks

In the Home Counties the term is applied to bricks made from limey clay in Kent and Essex. They are used in and around London on account of their high resistance to the London atmosphere, and are marketed in stocks and facings.

Rubbers

These bricks are used for brickwork in its most elaborate form and design; the possibilities in the construction of works of intricate ornamental design and delicate character are inexhaustible. These bricks can be cut and rubbed true to the most minute detail in columns, capitals, niches, oriel windows, pedestals, aprons, arches, architraves, etc. In London there are some fine examples of work in which rubbers were used; some of these examples were designed by Wren.

Fig. 3.—EXTENSIONS TO STUDENTS' UNION, UNIVERSITY OF LIVERPOOL
(*Architects : C. H. Reilly, L. B. Budden, J. E. Marshall, F/F.R.I.B.A.*)

Special Bricks

Special or purpose-made bricks are mainly used in facing work, and are mostly named to correspond to the purpose for which they are to be used, i.e. squints, plinths, cants, mitres, bird's-mouth, radius headers and stretchers, bullnose, with stops, external and internal angles, straight and return mouldings. A selection of the special bricks of which stocks are usually carried by manufacturers is shown on Data Sheet No. 25.

Keyed Bricks

These are used in situations where a good key is required for external or internal plastering.

Cellular Bricks

For present-day steelwork and reinforced-concrete buildings, walls are needed only to fill in the spaces between the beams and columns when concrete is used, and between stanchions and joists in the case of steelwork. It is to be noted that this class of building is so designed that each floor carries its own walls, and the steel and concrete work is so constructed as to carry all loads likely to be placed upon it, and this includes the walls. It is here that considerable economies can be effected by the use of a brick lighter in weight than hitherto. The cellular brick not only meets this need, but stands up to all the tests for strength and appearance.

Briquettes

Briquettes are, as the name implies, small bricks, many of which are used in fireplaces. They are usually sand-faced, rustic, or mottled, in fact they are facings in miniature.

Insulatory Bricks

Insulatory bricks are very light, and are principally used as non-conductors.

A specially made brick for reinforcement is made under patents and known as Morton's Ferrabrique System.

Flint-lime Bricks

Hunziker flint bricks are manufactured from crushed flint, mixed with lime, in various grades for use as common building bricks, facings, and engineering bricks. The standard colour is silver-grey, but first-quality facings are also made in a good variety of colours. It is claimed that they can be kept clean without abrasion in city atmospheres.

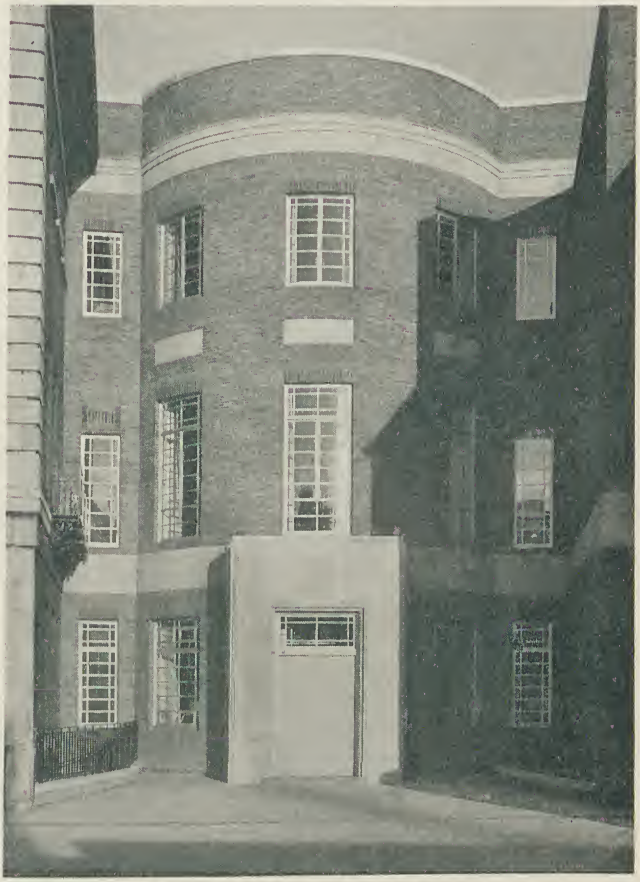


Fig. 4.—Extensions to Students' Union, University of Liverpool
(*Architects : C. H. Reilly, L. B. Budden, J. E. Marshall, F/F.R.I.B.A.*)

The Multivent Brick

This brick is somewhat larger than the standard brick both in width and in length, and is so constructed that a wall of Multivent bricks contains two vertical cavities.

Sand-lime Bricks

As the name indicates, these largely used bricks are made from sand and lime, which is made to combine chemically in the presence of steam to

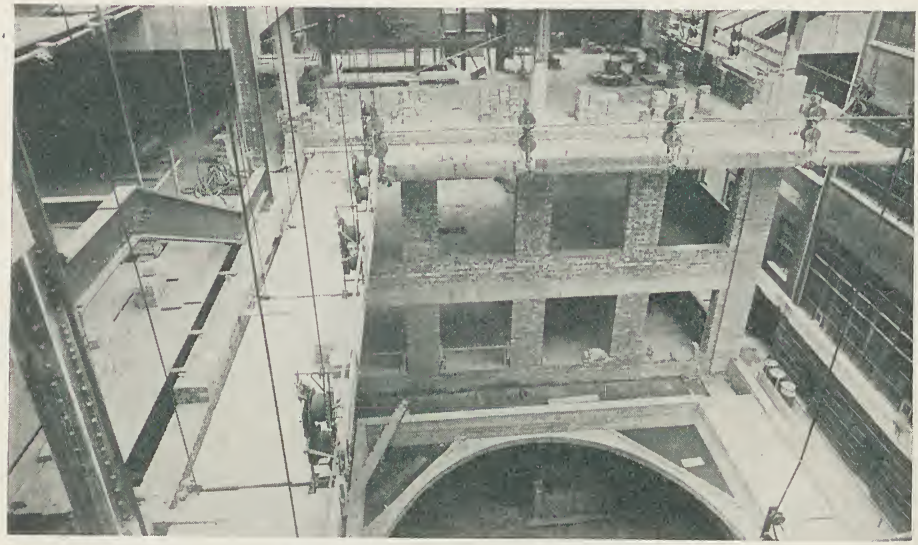


Fig. 5.—BRICKLAYING IN PROGRESS
Note hanging scaffolding suspended from rolled-steel joists above roof level.

form calcium silicate. The bricks are cheaper to make than most fired-clay types, and they weather well.

The normal colour is a white or pale buff, but reds, browns, and greys can be produced. They are very largely used as a substitute for the more expensive white glazed bricks. Their light-reflecting properties make them very valuable as facings for wells, etc.

Breeze Bricks

Breeze bricks are another variety usually built in walls to permit of fixing joinery.

Salt-glazed

Salt-glazed bricks are usually brown in colour, the glazing being formed by throwing common salt into the kiln during the burning process. This salt gives off a vapour which settles on the brick face, and gives a highly glazed and impervious surface. These bricks are particularly serviceable to form dados to corridor and stairway walls, also walls of lavatories, bakehouses, dairies, in fact, any wall facing where cleanliness is of paramount importance. They are easily cleaned, and generally comply with the regulations governing cleanliness in factories.

Glazed or Enamelled Bricks

These are made in multifarious variety of colours and shapes. Manufacturers are also prepared to make special shapes to meet varying

Fig. 6.—CHIGWELL U.D.C. OFFICES

Building faced with local red bricks of rough texture, with Clipsham stone dressings to windows, entrance, and parapets. Bottom picture: the Council Chamber. (*Architects: Tooley & Foster.*)

Fig. 7.—LAYING WHITE GLAZED BRICKS AROUND STANCHION

Note stanchion coated with Portland cement.

requirements, such as flat or camber arches, which would be impossible to cut from the standard brick, splays of different angles, mitres, bird's-mouth, etc. In fact, there is greater variety of specials made in glazed brick than in any other kind.

A Note on Jointing Glazed Bricks

A word here about the jointing of this class of brick may not be out of place. In good-class work it is customary to have fine and regular bed and vertical joints, hence the bricks are made slightly longer, wider, and thicker than those which form other parts of the building. The finish of the joints in white glazed work is often done with a white material, but this does not give the best results, as invariably the joint turns colour. A more satisfactory method is to have a contrast between the brick and the joint, for example, white glazed work appears at its best when laid and jointed with black mortar, the joint being rubbed in with a round jointer as the work proceeds, thereby forming a half-round recessed joint. Bricks in other colours would of course be treated in a similar manner, using a mortar which presents a contrast in colouring. Like the sand-lime brick, the glazed brick is particularly useful as a reflector of light.

PARTITION BLOCKS

Brick is not necessarily the best material for partitions. Hollow blocks, because of their light construction, have considerable advantages where reduction of weight is of importance. These are made in various sizes to suit almost any demand. They are also fire-resisting.

In addition to the patented hollow blocks, there are the more commonly made and used coke-breeze blocks and concrete blocks.

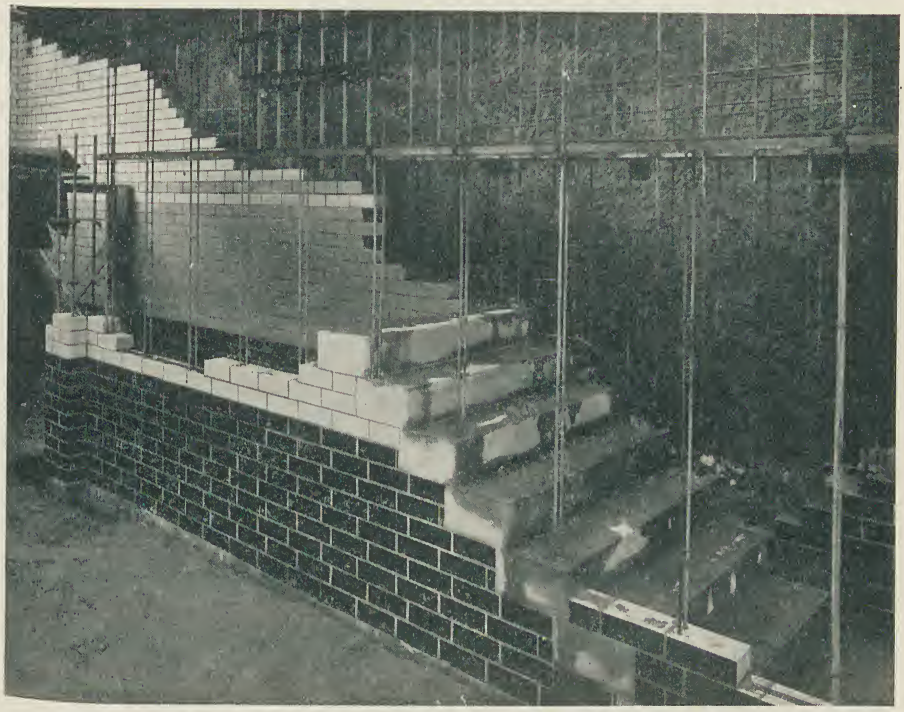


Fig. 7A.—AN EXAMPLE OF THE "FERRABRIQUE" SYSTEM OF REINFORCED BRICKWORK (*B. Morton & Sons*)

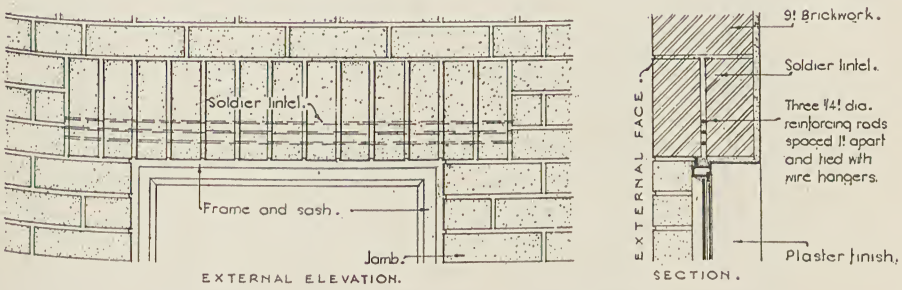


Fig. 7B.—APPLICATION OF REINFORCEMENT TO BRICK LINTELS

A simple insertion of reinforcement into the lower mortar joint, with the rods carried into the brickwork for a short length upon either side, eliminates the necessity for a concrete lintel or steel camber bar. (*London Brick Co. Ltd.*)

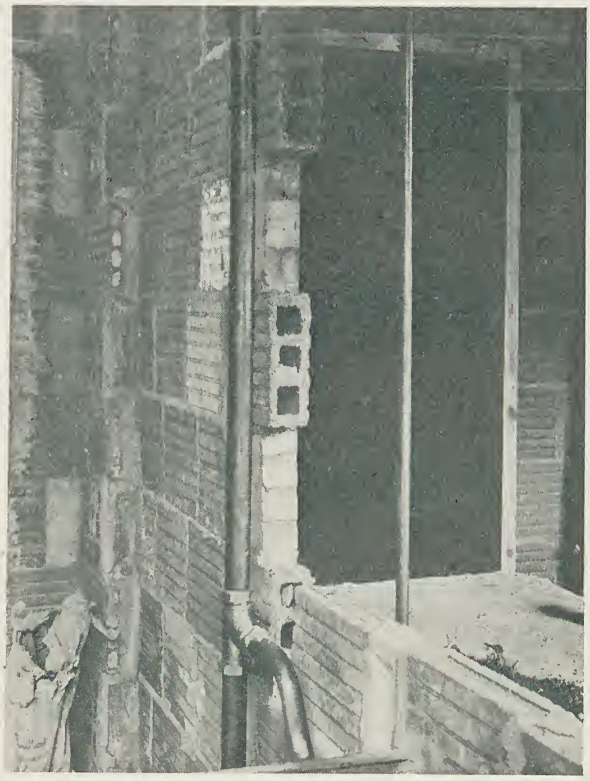


Fig. 8.—BUILDING WALL OF PARTITION BLOCKS

"Grip" Partition Brick

The "Grip" partition bricks are made in size 2 in. by 6½ in. by 9 in. When reinforced with wire they give great strength, and resistance to side pressure or vibration.

Sizes

That brick as a building material has always been used in large quantities is due in no small measure to its adaptability. The standardisation and size of bricks give the maximum weight and dimensions which can be comfortably manipulated by the human hand—and one hand alone, thus leaving the other free to handle the trowel. The standard sizes for bricks and joints are given in Data Sheets Nos. 18 and 19, with other useful data on brickwork.

ASBESTOS-CEMENT IN MODERN BUILDING PRACTICE

ASBESTOS-CEMENT, one of the most versatile building materials of the day, is a combination of asbestos and ordinary Portland cement. The former greatly increases the strength of the cement, so that the tensile strength of asbestos-cement is at least twice that of neat Portland cement. In the ordinary way asbestos-cement is composed of approximately 85 per cent. cement and 15 per cent. asbestos fibre. Some indication of the strength of this composite material is revealed by the fact that sheets only $\frac{3}{16}$ in. thick can be handled in sizes up to 8 ft. by 4 ft.

Asbestos-cement is being increasingly used in the building industry, for reasons that are readily appreciated by the builder and architect. The cost of asbestos-cement is comparatively low. The material is permanent, weather-resisting, fire-resisting, and immune from attack by rot or vermin. Asbestos-cement products require no painting or treatment of any kind, even when used out-of-doors. Other practical advantages are high tensile strength, low weight, and ease of working and handling. Most asbestos-cement building materials manufactured nowadays comply with British Standard Specifications.

Asbestos-cement Building-sheets

These are, of course, the oldest and still the most widely used of all asbestos-cement goods, and they find innumerable applications in all types of building, particularly for modern industrial plants.

Flat building-sheets of asbestos-cement are strong, permanent, fire-resisting, vermin-proof, non-corrosive, and provide insulation against heat and cold. They may be used indoors or out-of-doors to replace wood, plaster, stucco, or sheet metal. A considerable saving in labour can be effected by the use of these sheets for the covering of walls and ceilings. They are available in standard sizes of 8 ft. by 4 ft. to 6 ft. by 3 ft., and in thickness from $\frac{5}{32}$ in. to $\frac{1}{4}$ in. ($\frac{3}{8}$ in. and $\frac{1}{2}$ in. only in 8 ft. by 4 ft). Painting is quite unnecessary to prevent corrosion, but it may be considered desirable for decorative purposes. All that is needed is a preliminary priming which will prevent the lime in the sheets attacking the paint.

For outside work the effect of half-timber and plaster can be obtained by means of asbestos-cement flat sheets with creosoted boards covering the joints. An entirely new form of construction has been made possible by means of flat sheets and specially moulded asbestos-cement pilasters.

Embossed Sheets

Flat sheets with attractive embossed surfaces are available for interior walls, partitions, and ceilings. They form an ideal decorative medium when painted or distempered. The embossing is an integral part of the sheet, and can be treated in white, or one, two, or more tones and colours to give the effect of a plastic paint. Standard sizes are 4 ft. by 4 ft. and 8 ft. by 4 ft., of $\frac{1}{4}$-in. thickness, and with $1\frac{1}{4}$-in. flat border on one edge.

These embossed sheets are specially manufactured for the artistic decoration of indoor walls for the cinema, theatre, café, restaurant, entrance-hall, and office.

Asbestos Wallboards

These boards contain a much higher content of asbestos. They possess good insulating properties. Asbestos wallboard is fire-resisting, and possesses a good surface which can be painted without any previous treatment. The material can be fixed immediately on delivery from the works, without being "hung" or "aired" on site. It is supplied in sheets 8 ft. by 4 ft. and $\frac{1}{4}$ in. thick, and may be cut easily with a fine saw or sharp chisel, and screwed or nailed into position to either brick, concrete, wood, or steel structures or frames. See page 63, for notes on fixing.

Asbestos-wood

This material is known in the trade as "the building-sheet that will not burn," and is recommended for buildings and ships where fire-resisting walls or partitions are essential. In the R.M.S. *Queen Mary* the main bulkheads athwartship are composed of a composite board of plywood and asbestos-wood. These bulkheads, with the fireproof doors, divide the ship into a number of fire-resisting sections. To test the reliability of asbestos-wood as a fire-resisting material, stringent tests were carried out by the manufacturers in conjunction with the shipbuilders.

Asbestos-wood is not an ordinary asbestos-cement sheet, but it can be worked with simple carpenters' tools, and handled with ease. It offers no great resistance to a hand-saw with five or six points to the inch, which may be driven directly through the sheets, but holes for screws and bolts must be drilled.

The material is especially suitable for lining the walls, ceilings, and partitions in houses, garages, public buildings, cinemas, restaurants, industrial buildings, etc. It is economical in first cost, and is durable and requires no maintenance.

These sheets are supplied 8 ft. by 4 ft., and $\frac{3}{16}$ in. or $\frac{1}{4}$ in. thick.

Rough-cast and Pebble-dashed Sheets

The introduction of rough-cast sheets for covering timber-framed buildings is a comparatively recent development. They are available in two distinct types: the one with the rough-cast effect embossed on

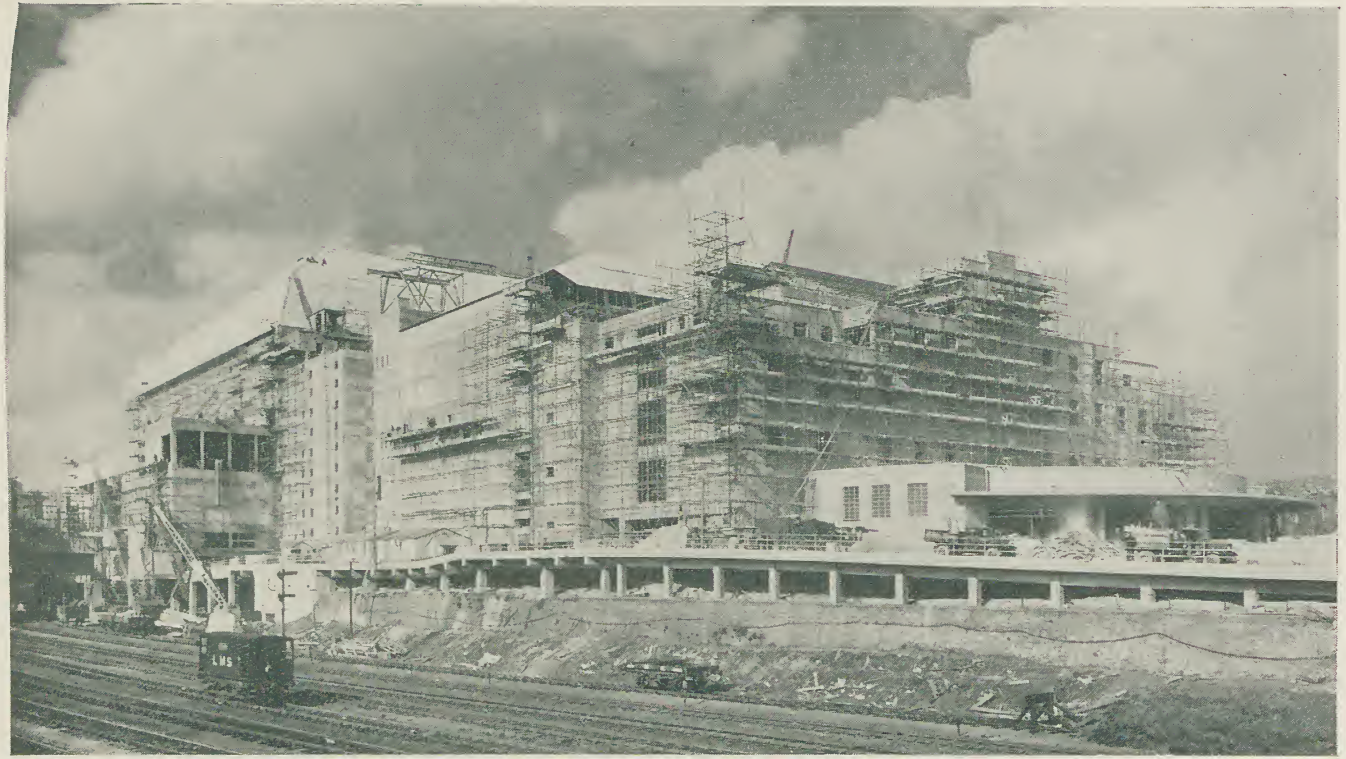


Fig. 1.—EARL'S COURT EXHIBITION

Progress photograph of the new Earl's Court Exhibition building which covers an area of 12 acres, similar in size to Trafalgar Square. The roof of the central and two upper side halls is of the hipped Mansard type and is entirely covered with "Turnall" Trafford tiles. 2,000 squares are covered with these asbestos-cement tiles. (*By courtesy of Turners Asbestos Cement Co.*)

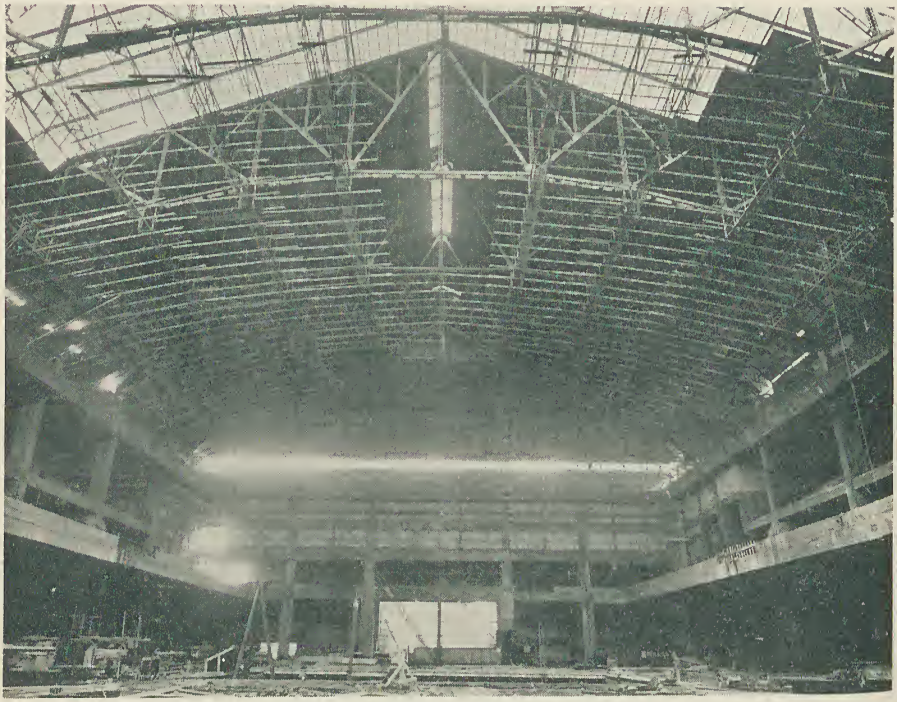


Fig. 2.—STUDY IN THE COLOSSAL

A progress photograph of the new Earl's Court Exhibition building, taken in the main hall, showing some of the roofing sheets in position. (*By courtesy of Turners Asbestos Cement Co.*)

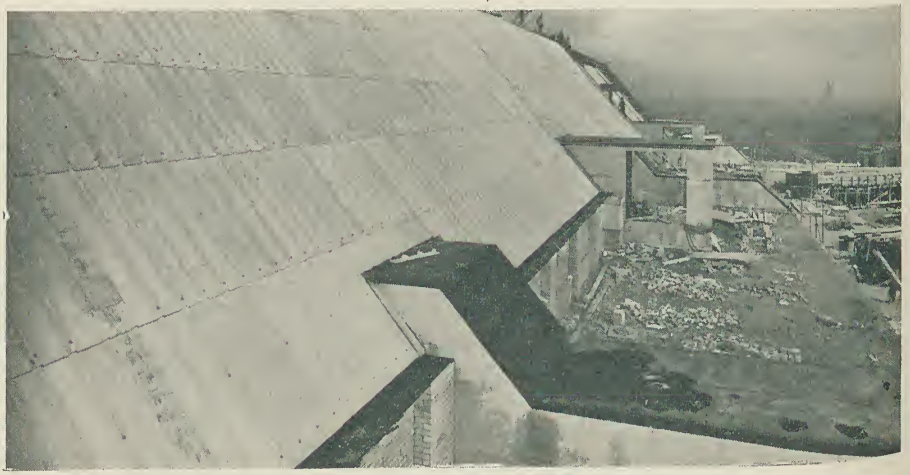


Fig. 3.—EARL'S COURT EXHIBITION BUILDING

Part of main hall roof, showing "Turnall" asbestos-cement Trafford tiles. All the gutters and rain-water goods are of "Everite" asbestos-cement. (*By courtesy of Turners Asbestos Cement Co.*)

asbestos-cement sheets, and the other in which actual pebble-dash, or white Derbyshire spar, is embedded in cement on the surface. Both types of sheeting provide a ready and economical medium for covering the walls of garages, pavilions, schools, hospitals, bungalows, etc., also for filling dormer cheeks, gable ends, bay windows, etc.; the method of fixing is extremely simple. The sheets should be fixed so as to allow approximately $\frac{3}{8}$-in. clearance between all edges. Timber framing needs spacing at 24-in. or 16-in. centres vertically, with horizontal rails at 4-ft. 6-in. centres.

The rough-cast sheets are 8 ft. by 4 ft., and $\frac{1}{4}$ in. thick, whilst the pebble-dashed sheets are the same size, but double the above thickness.

Asbestos-cement Roofing Materials

Asbestos-cement slates, tiles, and corrugated sheets for covering roofs are dealt with on pages 241 to 245.

Building-slabs

These slabs are supplied in a standard size 6 ft. by 2 ft. 6 in. wide, and nominally 2 in. thick, for flat or low-pitched roof construction, and for this purpose joists may be spaced up to 6-ft. centres.

The hollow construction of these slabs makes them very light, though strong and easy to handle. They also possess excellent insulating properties.

The method of joining the slabs on a flat roof is very simple, and consists of jointing with cement mortar and laying in a similar manner to pavement slabs, making sure that the joints of the slabs are resting on the supporting joists and not overhanging in cantilever fashion.

When the spacing of joists is 6 ft., the slabs should be laid in even rows, but for construction with a spacing of joists at 2-ft. or 3-ft. centres the joints may be staggered as desired.

Transverse tests on the 6-ft. by 2-ft. 6-in. panels showed them able to withstand a weight of as much as 1,476 lb., the load being applied over a 2-in.-wide strip extending the whole width of the panel placed centrally between the supports.

Tensile-strength tests carried out on pieces 12 in. wide by 1 ft. 3 in. long showed the load at failure to be 1,060 lb. actual when weight was applied to rods in corrugations, and 808-lb. load at failure when rods were on the flat surface.

End-compression and crushing tests also gave eminently satisfactory results.

Asbestos-felt

This has a mineral base of asbestos fibres filled with mineral bitumen. The combination of these two substances results in a long-wearing weather-resisting material which effectively stands up to all weathers, while

maintaining its original impervious characteristics. This material is unaffected by heat or cold, chemical fumes, gases, salt air, or changes in temperature, and will stand the test of time.

Asbestos-roofing felt is easy to lay, and can be applied to boarded pitched roofs, or between the spars and the slate laths, and also built up in layers for flat roofs.

The standard measurement for the uncoated felt is 24-yd. by 1-yd. rolls, and the weight per roll is 30 lb. The special fire-resisting grade is available in rolls of 12 yd. by 1 yd. and weighs 63 lb. There is a number of coated felts for special purposes.

Rigid Rubber Tiles and Slabs

A description of these is given on page 20, Vol. II.

Asbestos-cement Pressure Pipes

The experimental manufacture of asbestos-cement pipes by the process invented by Comm. Mazza was commenced in Italy in 1913, and by 1916 it had been established on a commercial basis, and these pipes were being adopted for water-mains service in Italy. Their great advantages of economy and freedom from corrosion or incrustation were readily apparent, and the durability of asbestos-cement had already been proved by its use for roofing materials, which had then been in use for more than ten years.

In Italy a section of a pipe line at Casale Monferranto, which had been in use for 17 years carrying soft water at a pressure of 100 lb. per square inch, was taken up and examined. Not only was the pipe in perfect condition, but physical tests showed that its strength had increased by over 40 per cent. compared with pipes of identical bore and thickness made at the same time which had been tested to destruction six months after manufacture in 1917.

The manufacture of asbestos-cement pipes was commenced at Widnes in 1928. In September 1929 an exhaustive series of tests carried out under the supervision of the chief engineering inspector of the Ministry of Health and his staff showed that these pipes were able to stand up to any conditions of service. A loan period of twenty-five years was approved for asbestos-cement pressure pipes, with the bolts in the detachable joints, where these are adopted, suitably protected with bitumen against external corrosion. The following year the Department of Health for Scotland agreed to approve these pipes for the full period allowed for cast-iron pipes, namely thirty years.

In April 1933 the British Standards Institution issued British Standard Specification N. 486/1933 for asbestos-cement pressure pipes.

These pressure pipes have a smooth and truly cylindrical bore. As the pipes cannot corrode or accumulate internal incrustations, their very high initial carrying capacity does not diminish as the life of the main increases.

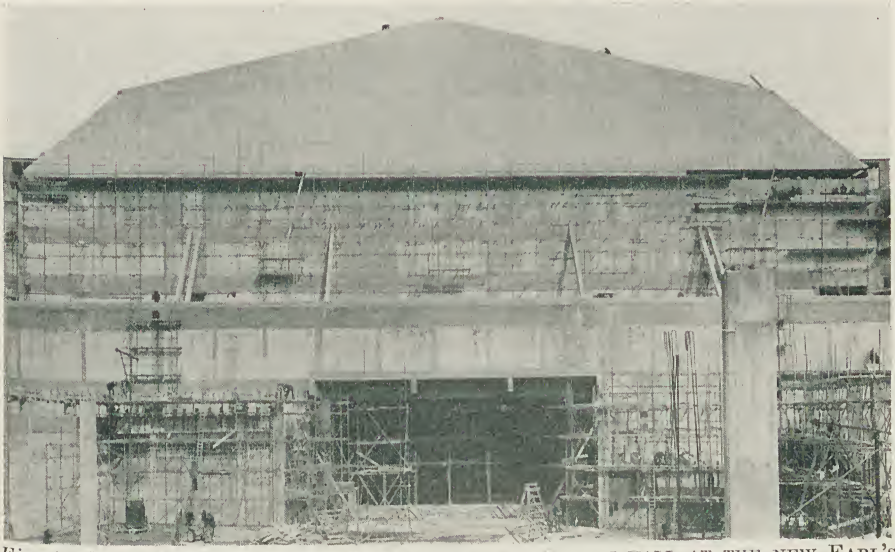


Fig. 4.—PROGRESS PHOTOGRAPH OF THE BACK OF THE MAIN HALL AT THE NEW EARL'S COURT EXHIBITION, TAKEN FROM THE EMPRESS HALL

The Mansard roof, which is of " Turnall " Trafford tiles, is clearly shown. (*By courtesy of Turners Asbestos Cement Co.*)

Fig. 5.—MODERN AERODROME CONSTRUCTION

A new aerodrome in the Midlands. The roof and vertical slating is of " Poilite " Newtone asbestos-cement slates. The rain-water goods are also of asbestos-cement. (*By courtesy of Turners Asbestos Cement Co.*)

Fig. 6.—"TURNALL" BUILDING SLABS AS FOUNDATION FOR A FLAT ROOF
This photograph shows these slabs being fixed in position. A roof of these slabs can be laid quickly without shuttering or sheeting. (*By courtesy of Turners Asbestos Cement Co.*)

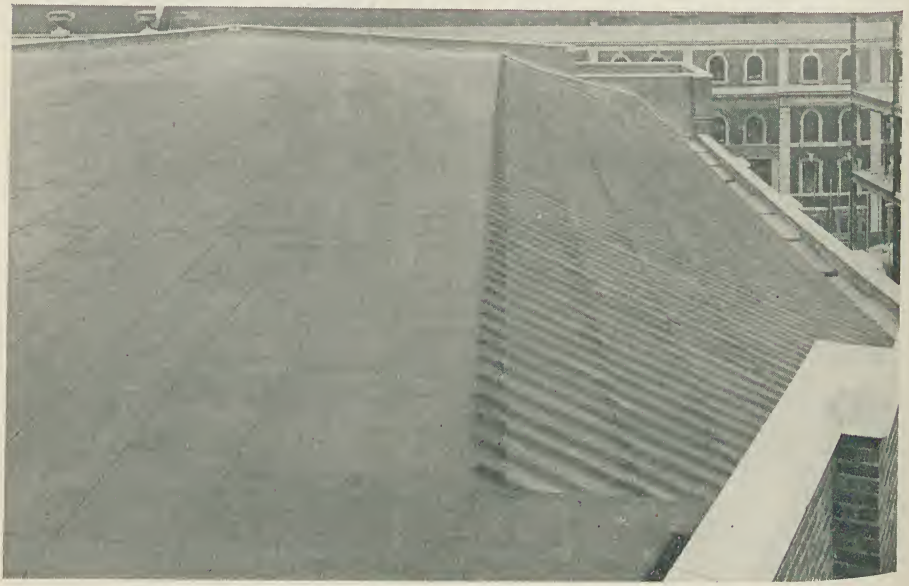


Fig. 7.—ROOF OF PARAMOUNT THEATRE, TOTTENHAM COURT ROAD, LONDON
The foundation of "Turnall" building slabs has been completed with built-up "Serval" asbestos felt. The Mansard roof is covered with "Turnall" Trafford tiles. (*By courtesy of Turners Asbestos Cement Co.*)

Whilst being exceptionally strong, the pipes are very light and may therefore be cheaply transported, handled, and laid. The flexible joints used with asbestos-cement pressure pipes may be made with unskilled labour in a fraction of the time required for ordinary caulked-lead joints. Drilling and tapping for service connections can be undertaken as easily and quickly as in the case of metal pipes, and the asbestos-cement pipe can be easily cut with a hack-saw.

Rain-water Goods

The advantages claimed for asbestos-cement pressure pipes apply with equal force to rain-water goods made of asbestos-cement. Fittings can be exposed to the rain and atmosphere without deteriorating or disintegrating. There is thus no need for any kind of protective painting, and once the goods are in position they can, to all intents and purposes, be forgotten, as they involve no maintenance or repair charges. Apart from the fact that asbestos-cement rain-water goods require no painting, they possess other important advantages.

They are very light, can be fixed without difficulty, and actually harden after they have been fixed. As far as erection costs go, another important factor is that these goods can be cut with an ordinary saw.

These asbestos-cement gutters and fittings are supplied ready holed for jointing with $1\frac{1}{2}$-in. by $\frac{5}{16}$-in. gutter bolts. In addition to the gutter bolts, however, a special jointing composition should be used as a bedding medium, instead of red lead, putty, or any other compound which is liable to lose its nature and become unduly hard.

The stated dimension of these gutters and fittings is between the two inside top edges, a point which should be remembered, as it is a different method of measurement from that employed in the case of metal fittings. In addition, the section of the inside of an asbestos-cement gutter is actually a full half-round and not a shallow section, as is often the case with light castings. It will thus be apparent that asbestos-cement gutters have a much larger carrying capacity than the corresponding size in metal, and the 4-in. gutter is almost identical in carrying capacity with a $4\frac{1}{2}$-in. metal gutter.

Soil Pipes

Asbestos-cement soil pipes are comparatively recent productions, but they are now widely recommended for large housing schemes. They are easy to fix in position, and more economical than similar pipes in metal. The introduction of the longer pipe, 10 ft. instead of the normal, frequently enables one or two joints to be eliminated in a single stack of pipes. The asbestos-cement soil pipes are lighter to handle than cast iron, and the 10-ft. pipe is lighter in weight than a 6-ft. by $\frac{3}{16}$-in. cast-iron pipe of similar bore.

Joints in these soil pipes can be easily and rapidly made with a gasket

of tarred hemp, above which bituminous compound to a depth of about 1 in. should be inserted. A neat mixture of cement, just moist, is then caulked, and this forms a perfectly sound, tight joint.

Flue Pipes

Asbestos-cement flue fittings have a polished surface which is clean and dust-free ; also a reasonably smooth inner skin which reduces skin friction to a minimum. The life of the pipes and fittings, under normal conditions of service, is everlasting. This is due to the fact that the materials of which they are made, asbestos and cement, are non-corrosive and strengthen with age. They withstand flue temperatures up to 500° F. Direct contact with flame must, however, be avoided.

Whereas metal and, indeed, most other materials cause troublesome condensation, asbestos-cement ensures freedom from condensation owing to the fact that it possesses good insulating properties. The heat is thereby retained in the flue, ensuring an efficient up-draught, effective dispersal of the products of combustion, and a minimum of moisture from condensation. Such moisture as may form is taken up by the inner skin of the pipe and subsequently evaporates. The pipes and fittings can be decorated if desired—all that is necessary is a preliminary grounding.

Ducts and Ventilators

Where air-conditioning ducts are not constructed from brick or concrete on the site there is a demand for prefabricated sections in a material reasonably strong, light, and easy to handle, and as the sections are often inaccessible for replacement or repair the material must be able to withstand corrosive attack. Asbestos-cement is not only ideal from these points of view, but it is also a good insulator and will minimise heat loss through the walls. Even when the ducts are to be constructed of concrete, asbestos-cement sections are an economical and efficient medium for use as internal shuttering for concrete, and should be retained in position after the outer timber shuttering has been struck. The very smooth bore of asbestos-cement ducts increases the efficiency of concrete ductwork, since it reduces air friction.

Standardised asbestos-cement ducts are now available in circular or rectangular sections, and specials of any kind can be produced to suit individual ventilating problems, thus enabling complete ducts to be prefabricated for each installation, either inside or outside a building.

Asbestos-cement ventilators have the advantage of not being corroded by exposure to weather or fumes.

Cable Conduits

Asbestos-cement cable conduits were first produced a few years ago at the special request of certain engineers. There is no difficulty in supplying all diameters of conduits in 10-ft. lengths, and as single-way con-

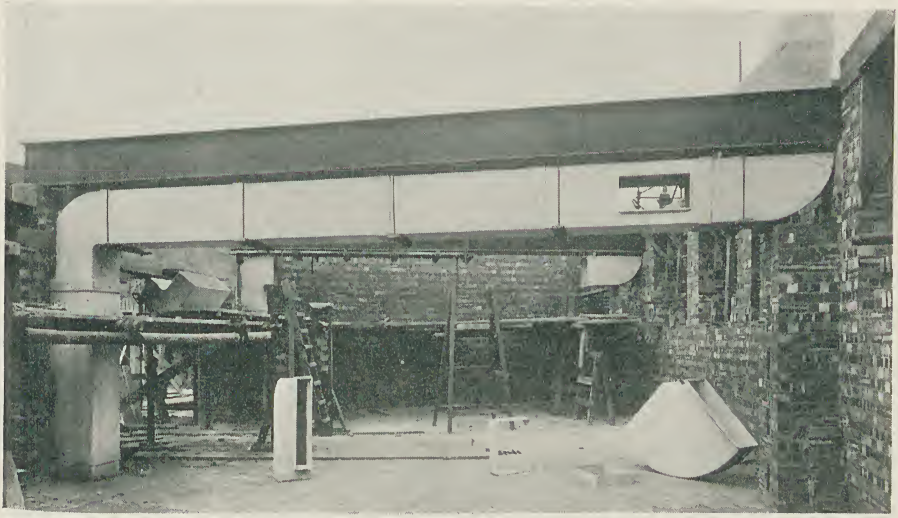


Fig. 8.—"EVERITE" VENTILATING DUCTS BEFORE BEING BUILT INTO THE STRUCTURE
(*By courtesy of Turners Asbestos Cement Co.*)

duits of this length can be readily handled by one man, the heavy handling charges of earthenware are automatically cut out, and owing to the reduction in the number of joints the laying of a line of conduit is expedited.

The results of the tests to establish the coefficient of friction between a standard cable and the various types of conduits are of interest to all mains engineers.

(1) Asbestos-cement conduits	Coefficient	0·696
(2) Earthenware conduits	,,	0·906
(3) Fibre conduits	,,	1·189
(4) Cast-iron conduits	,,	1·322

It will at once be appreciated that only approximately half the pull is required in the case of asbestos-cement conduits compared with that required when fibre is used.

Decorated Sheets

Decorated asbestos sheets may be used for practically all purposes where marble slabs or tiles, ceramic tiles, plaster slabs, enamelled sheets, and the like are used for interiors.

The sheets are available in sizes 6 ft. by 3 ft., 6 ft. by 2 ft., and 3 ft. by 3 ft., approximately $\frac{5}{16}$ in. thick, and in slabs faced both sides $\frac{1}{16}$ in. thick. All the sheets possess a natural veining which closely resembles marble, the colours being available in sixteen variations. The sheets should be fixed by screwing direct to plugs or battens.

Plain asbestos sheets with highly glazed surface in pastel shades are

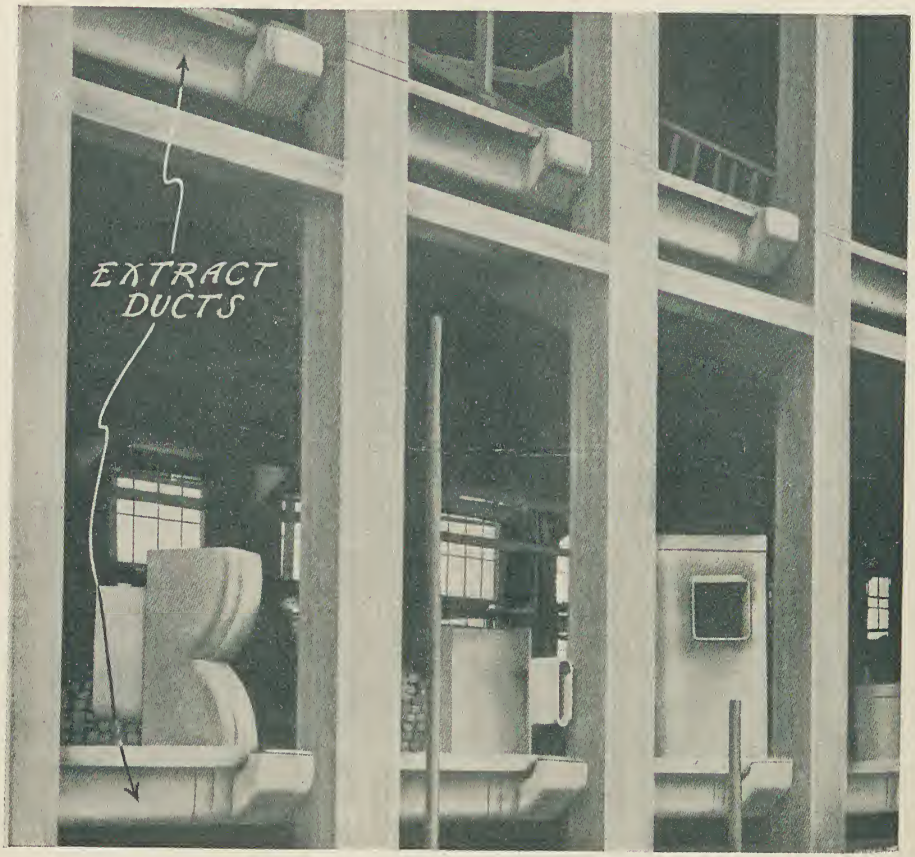


Fig. 9.—ASBESTOS-CEMENT DUCT WORK

" Everite " asbestos-cement extract ducts with inlet branches before the construction of walls and ceilings, when they are completely encased in the structure. (*By courtesy of Turners Asbestos Cement Co.*)

available in two standard sizes, 6 ft. by 3 ft. and 6 ft. by 2 ft., of approximately $\frac{1}{4}$-in. thickness. Five shades are available in the colour range, and in addition there is a shaded green, primrose, and ivory sheet which has been designed to provide a variant that is both pleasing and unusual. These sheets will withstand all conditions, such as prevail normally, for example, in bathrooms and kitchens.

Glazed panelling sheets—another type of asbestos-cement product—apart from the ordinary decorative uses, are used for gas and fire surrounds.

The range of colours includes plain colours, fancy colours, black, gold, red, green, also wood types, such as oak, walnut, mahogany. They are manufactured in the following standard sizes : 6 ft. by 3 ft., 6 ft. by 2 ft., 6 ft. by 1 ft. 9 in., and 3 ft. 4 in. by 3 ft. 4 in. ; the approximate thickness is $\frac{5}{16}$ in.

Glazed flexible sheets are also available, suitable for curved surfaces.

Fig. 10.—ROOF LAID WITH "POILITE" ASBESTOS-CEMENT PANTILES

(*By courtesy of Turners Asbestos Cement Co.*)

Stipple-glaze and plain white sheets in two standard sizes—8 ft. by 4 ft. and 4 ft. by 4 ft., thickness approximately $\frac{1}{4}$ in.—find wide application for bathroom and bath panels, refrigerators, cold-storage chambers, and shop interiors.

Many of the decorated sheets described may be used for covering in the domestic bath, and as splashbacks. Special moulded panels are also available for this purpose. These can be fixed on a simple wooden frame arranged round the bath so that the panels are caught under the lip of the bath and give an exceedingly neat finish. These moulded panels require priming and painting.

For interior decoration, oak-grained asbestos panels of modern design are available. The panels are faithful reproductions of specially selected oak. The grain effect is not merely superimposed, but is actually

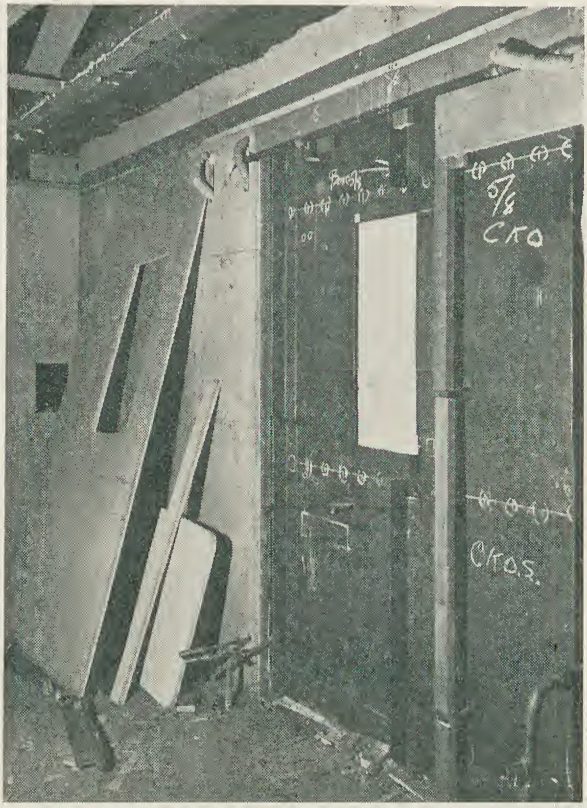


Fig. 11.—A PROGRESS PHOTOGRAPH TAKEN DURING THE FITTING OUT OF THE R.M.S. "QUEEN MARY"

"Turnall" asbestos-cement composite boards supplied in conjunction with Messrs. L. Keiser & Co., Limited, of Leith, were used to provide the ship with a number of fire-resisting bulkheads. (*By courtesy of Turners Asbestos Cement Co.*)

moulded in the surface of the panels. The colour is of the popular light-oak effect, which adds tone to any room. The panels are fire-resisting, and useful for the lining of exit passages in theatres and cinemas, where authorities will not allow timber to be used. There is no expansion or contraction. The material is unaffected by damp, and is proof against all attacks of wood-borers or rodents.

The panel is supplied in four parts, viz. the panel, frieze rail, skirting, and skirting block. The sizes are as follows :—

Panels, 6 ft. by 1 ft. 8 in.
Frieze, 8 ft. by $7\frac{1}{2}$ in.
Skirting, 8 ft. by $7\frac{1}{2}$ in.
Skirting block, 8 ft. by $1\frac{3}{4}$ in. by $\frac{3}{4}$ in. thick.

BUSINESS ORGANISATION FOR THE SMALL BUILDER

DURING recent years enormous and far-reaching developments have taken place in building construction and design, necessitating radical changes in methods of control and general administration, and these developments have coincided with a widening of the sphere of the country's banking and commercial credit systems. No longer is it possible for the builder to ascertain the margin of profit realised during a particular accounting period by referring to his bank book, for in modern building enterprise credit plays an important and frequently a principal part, and experience proves that the builder who neglects the financial and book-keeping side of the business is operating at a great disadvantage as compared with the builder who knows his costs, and is able to base estimates and quotations on work of a similar nature in connection with which suitable accounts and records were kept.

How System Helps

In the matter of taxation the importance of system is very much in evidence at the present time. No builder desires to pay more tax than his fair share, and to avoid any arbitrary or excessive assessment of their profits many are compelled, in their own interests, to seek a greater or less degree of professional or legal assistance—and often both—in the computation of their tax liabilities. The adoption of a suitable system of book-keeping and internal check would enable such expenses to be reduced to a minimum, and in many instances avoided altogether, while at the same time full advantage could be taken of the various deductions and allowances to which, as a taxpayer, the builder is entitled by the statutes.

The ability to prepare reliable accounts, financial statements, and cost statistics at any time is of incalculable value to the practical builder. But that many jobbing builders, plumbers, fitters, and electricians have completely failed to appreciate the importance of good book-keeping can be proved by an examination of the bankruptcy files. Instead of being due to any inherent weakness, a large proportion of failures in the building and associated trades is the direct consequence of failure to keep proper books of account in accordance with modern double-entry principles, based on the special features of building-trade accounts.

Need for Double-entry Methods of Book-keeping

The difficulty experienced by some small builders in appreciating the need for the adoption of double-entry methods can, however, be overcome by keeping in mind the twofold aspect of all business transactions. When any bricks, tiles, blocks, insulation boards, or other materials of a similar nature are purchased, for example, the builder's stock will be increased by the amount equal to the cost price of the materials, but his cash or bank balance will be correspondingly decreased; or if the materials have been bought on credit, a business liability will be created in the process, necessitating two separate entries in the financial books, one entry giving effect to the increase in the stock, and the other entry registering the decrease in the liquid resources, or the creation of the liability, as the case may be. In like manner, when paint, distemper, enamel, or white lead, etc., is taken from stock for use on a contract, it would obviously be incorrect simply to record one side of the transaction by means of a single entry on the credit side of the stock account, as the cost price of the stores constitutes a proper charge against the job or contract, and should be shown as such in the books, and the same principles apply to every building operation, without exception. Indeed, the outstanding advantage of double-entry book-keeping lies in the fact that for every amount recorded on the left-hand or debit side of one book or account, there is a corresponding credit entry in another book or account, for this enables the clerical accuracy of the entire records to be verified by drawing up a trial balance, or summary of ledger balances, from which reliable trading accounts, profit and loss accounts, and balance-sheets can be prepared at convenient dates.

The Things on Which the Builder Must Keep a Check

To be in a position to obtain all and any information, the builder will have to keep several subsidiary books and ledgers, apart from the ordinary working-books. The chief questions usually raised, and to which the books of account are expected to furnish accurate replies, may be enumerated as follows :—

(1) What was the total value of the job and contract work last month; and how does the figure compare with that for the corresponding month a year ago ?

(2) Does the internal system in operation ensure that all grates, pipes, pots, shutters, doors, screens, sanitary goods, etc., issued in connection with the different operations and jobs on hand, are properly accounted for; or is there any possibility of errors or irregularities taking place ?

(3) Is proper control being exercised over issues of materials and stores; and are adequate charges made against the different jobs in respect of materials and stores actually used ?

(4) Under what specific headings do the trade purchases fall; and is any stock allowed to dwindle below the minimum which experience

has proved necessary or desirable to carry in order to satisfy current requirements ?

(5) Of what do the management and working expenses consist ; and under what headings could economies be safely effected ?

(6) What is the capital outlay to date in the form of lifting-gear, grinding- and polishing-machines, paint sprayers, etc. ; and is a sufficient sum charged against the different jobs to cover the depreciation of all wasting assets which have had to be employed ?

(7) Are general building repairs recorded in a proper manner ; and are the charges for decorating, cleaning, and restoration booked correctly?

(8) Am I taking full advantage of rebates and discounts allowed by suppliers ; and if not, why ?

(9) Does the percentage of net profit in relation to turn-over and invested capital compare favourably with previous financial years or accounting periods ; and are any losses being sustained ?

(10) What is the present value of the various business assets used for profit-earning purposes ; and what is the total and the composition of the building liabilities ?

The correct answer to the above and other equally important questions asked by the practical man from time to time depends largely upon the institution of suitable accounting and costing methods.

Estimating

At the present time builders are adopting various methods of estimating the cost of jobs and operations, the procedure varying according to the size of the business or the class of trade. Many small builders depend entirely upon guesswork when placing a value on a piece of work, especially if similar jobs have been carried through many times before, but experience has proved that guesswork may sooner or later have very disastrous consequences, and it should be altogether avoided in connection with new or unfamiliar processes or types of job. That a certain amount of guesswork will have to be applied cannot be denied, but instead of guessing blindly it is much better to keep proper records that will enable reliable estimates to be arrived at, and will ensure an adequate margin of profit on completed jobs. By so doing, errors and irregularities can be kept within narrow limits. For some classes of work a guess may be registered as to the cost, but upon taking measurements and making calculations on the basis of the square yard, the figure arrived at may be very different from the original rough guess.

Generally speaking, it is advisable to measure all sections of the work in square yards, enabling the total area to be arrived at. With regard to materials, the prime cost may be calculated on the basis of the dimensions, sufficient allowance being made to cover wastage, spillage, carriage, and other contingencies, while the prime cost of labour should be determined by reference to the accepted time unit applicable in the trade in the

district. To the prime cost of materials and labour should be added a reasonable sum for overhead charges, fixed expenses, supervision, plant, etc., and to this total must be added the amount of profit it is desired to realise on the particular job or operation.

The sheets used for the actual estimates and calculations should show the materials and labour costs quite distinct, owing to the wide variations frequently existing between the two debits. Types of buildings differ very materially, as also do the qualities of the materials used, and while it may be a relatively simple matter to work out the cost of the materials and stores needed, to estimate the number of hours the operation will take may be much more difficult. For example, in calculating the costs of one job the materials cost may be three or four or even five times greater proportionately than in the case of another job, where the cost of materials will be comparatively small. The same will apply to an even greater extent with the labour costs, one job needing a much larger staff, with consequent increase of labour costs, as compared with another of relatively equal size. Moreover, as the information relating to the prime cost will be obtained from different sources—the materials cost being shown in the stores book, and the labour cost on the time-sheets or job cards—the actual costs and the estimates can be quite readily compared if the time-sheets records have been separated from the records of materials used.

The wide divergence in estimates for building work and kindred jobs is due to different methods of carrying through the same or very similar jobs. In some instances, cost may even be a factor of small importance so long as the desired result is obtained, whereas many other contracts have to be completed in strict accordance with accepted principles involving accurate measuring up and costing. Other contracts may be carried out at relatively low costs, owing to the fact that the work will have to be repeated in the near future. To commence any job without due consideration of its full requirements may mean the waste of many hours of valuable time and even loss of profit, and before work is proceeded with the client should be advised as to what is necessary to give satisfaction to both parties.

The Work of the Estimator

When a client makes known his desire to have building work carried out, it is the work of the estimator to complete the quantities and specifications. The estimator's sheet would show the name and address at the top, also the date, followed by the number of the job, the date on which the work is to commence, and the date on which the job should be completed. The actual work to be performed should be clearly described, the exact sizes and heights of rooms and other details being set down to enable the prime cost to be taken out and recorded. To the total prime cost must be added an amount representing establishment charges, also

the profit, to arrive at the total estimated cost. Each form of estimate should embody words to the effect that it is agreed to do the work mentioned (in the specification attached) at a given place for a definite sum, which sum should be stated in words and figures, and care should be exercised to ensure that the particulars of the work agree with those shown in the estimator's book.

The Estimator's Book

The book used for the insertion of the details may be of the loose-leaf type, the top cover folding back with the leaves. Directly the particulars of a job have been completed, the whole of the leaves can be removed and attached to each other for transfer to the person or department dealing with these matters.

The Job Card

The man in charge of the particular job will be supplied with a job card giving all the essential details, such particulars as the estimated costs being, of course, omitted.

When Work Is Under Supervision of Architect

Specifications relating to work to be carried through under the supervision of an architect are usually drawn up in the architect's office, and in some instances the quantities are taken out. References made to special materials should be carefully noted, as it is necessary that the architect's instructions be faithfully carried out ; while on the other hand it is essential that the architect's attention should be directed to any details which have been omitted or to any section of the job demanding more preparation than has been allowed for in the specification.

Requisitions

Requisitions used in support of materials and stores issued from stock from time to time should be sorted out in a systematic and business-like manner under such headings as bricks, stone, slates, tiles, and terra-cotta, metal and timber, paints, varnishes, and enamels, etc., enabling the materials cost to be properly allocated.

Recording Labour Costs

The labour involved in the different operations will be recorded by the foreman, or charge-hand, on time-sheets showing the number of the order or job ; details of the work actually performed and the number of hours worked by each man. The basis for calculating the amounts to be inserted on the time-sheets or cards will be the weekly rate of pay, in each instance, and directly these figures have been determined and added up,

it is advisable to add a small percentage to the total to cover the departmental charges, the figure ultimately arrived at being transferred to a cost book, where it should be shown under the general heading of "labour," as well as a charge against a particular job, estate, or contract.

While in many instances it will be sufficient for all practical purposes to show the total labour costs in one amount, it is sometimes considered necessary or desirable to analyse the costs under such heads as roofing, machining, loading, pumping, installations, etc., or bricklaying, plastering, painting, joining, excavating, and fitting. When such a classification is undertaken, the time-sheets should be provided with a number of columns or sections, sufficient space being also reserved for summarising the total costs under the different headings. Usually, it is not deemed essential to analyse each operation under the various sub-headings, the charges for work or service of a similar nature or description being preferably lumped together. For example, if a section is provided for electrical work, the time spent in the installation of cookers and similar products should be shown in that section of the time-sheet, while a general heading for timber would include the cost of fencing, etc. Having once fixed the most appropriate headings, the time-sheets can be divided accordingly, ample provision being made, of course, for the insertion of the name and address of the client or estate, the job or order number, the date of completion, and for any special observations or remarks.

Dealing with Materials of Bulky Nature

Many practical builders in this country have now equipped themselves with separate stores for materials of a bulky nature, the use of which is confined almost entirely to a particular class of operation. Such stores are usually placed in the charge of a foreman, who has the keys in his possession, and who is made responsible for keeping accurate records of everything received and issued. The foreman should know the particular job in the fulfilment of which materials or stores have been used, and in practice this system very greatly simplifies the control of operations, and affords an excellent internal check that has the effect of preventing fraud and pilfering on the part of dishonest hands, and of avoiding errors, irregularities, and waste.

Docket System

In some districts, dockets are used rather extensively, and are usually printed in sets of four, each form being of distinct colour to enable one to be used in the yard, one in the workshop, one in the stores, and the other to be retained for use in the office. These dockets should be numbered in strict rotation, all the forms of the same set bearing identical numbers, and showing the date and the job number, with a detailed description of

the work to be performed. These particulars should be set down at the top of each form, on either the pen or the pencil carbon-copy principle, and as soon as all the forms making up a set have been collected in the office, they should be stamped to show the date of completion, while the summaries can be made out without delay, giving the time spent and the materials and stores used.

Contract Work

Building work undertaken on a contract basis necessitates the keeping of separate contract accounts, on the left-hand or debit side of which will appear the labour costs, the materials and stores consumed, the fittings used, and an adequate amount to cover overhead charges. When the overhead charges are provided for by means of a percentage, this percentage should correspond, as nearly as possible, with the ratio which the total of the establishment charges during the last full year or accounting period bears to the total wages paid out, plus the purely trade purchases for the same period.

Wages Sheets

As one of the largest items of expenditure will fall under the heading of wages in the ordinary books of account, the internal organisation of the working operations is a matter of great importance to the builder. Where possible, it is advisable to arrange matters so that each worker regularly records the particular duties performed each day, the cards on which these records are made being initialled by the foreman, whose time records should be passed on to the office as a matter of daily routine. If the workers are accustomed to clock in on a special job, the clock records should also be handed in at the office to enable comparisons to be made with the foreman's records. From the daily time records, the wages sheet can be made out, giving the names, rates of pay, the total hours worked each day, and all deductions, and directly the amounts due to each worker have been worked out and checked, the figures on the sheets can be added and the details copied into the wages book.

Wages Book

Various styles of wages book are in use at the present time, ranging from the simple pattern of book to the analytical wages and labour distribution book. The simple form usually includes columns for the insertion of the number and name of each hand, the hours worked, the rate payable, the total deductions, and the net amount. Where an analysis of the wages is found to be essential, the book should be provided with sections under such headings as yard labourers, blacksmiths, machinists, joiners, and polishers, etc., care being exercised to ensure that the wages paid out to men engaged on work of a capital nature are not mixed with

the building labour costs. A good general form of wages book and labour distribution analysis is given herewith :—

WAGES BOOK AND LABOUR DISTRIBUTION ANALYSIS

WAGES AND INSURANCE

Number	*Name*	*Hours Worked*	*Rate of Pay*	*Gross Wages*			*Deductions*										*Net Wages*			*Employer's Contributions*									
							Health Insurance		*Unemployment Insurance*		*Hospital*									*Health Insurance*		*Unemployment Insurance*		*Hospital*					
				£	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	£	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*

LABOUR DISTRIBUTION

Job No.	*Particulars*	*Masons*			*Bricklayers*			*Plasterers*			*Carpenters*			*Painters*			*Machinery, Plant, and Equipment*			*General*		
		£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*

Entering Up Sums Paid Out as Wages

The total sum actually paid out as wages will be recorded on the credit side of the general cash book, or in the cash payments book, as the case may be, from where it would be posted direct to the debit side of wages account kept in the nominal or expenses ledger.

Dealing with Depreciation of Equipment

When preparing the periodical profit and loss account indicating the margin of net profit realised during the year, or other accounting period, and in drawing up a balance-sheet intended to exhibit a true and correct view of the state of affairs on a given date, a most important factor is that of depreciation of the various assets and groups of equipment which have been employed in the business for the purpose of earning profits.

In addition to constituting one of the most controversial subjects in the field of modern accountancy, the subject of depreciation is probably the one subject most liable to be treated with neglect or indifference on the part of the master builder, the partners, or the directors, as the case may be. Some builders contend, for instance, that if the equipment is maintained in good condition, the current period should not be burdened with a depreciation charge in addition to the cost of repairs and upkeep, and the majority of builders established on their own account are very much inclined to regard as meaningless the valuations placed upon the business assets by the customary methods of computing depreciation, unless the final figures arrived at for balance-sheet purposes have some very direct relation to the prevailing market values of the particular assets which have been subjected to deduction to cover shrinkage in value.

The amount of capital now invested in lifting-gear, tractors and trailers, floor-surfacing machines, disc sanders, paint sprayers, and other essential building and engineering equipment is, of course, very considerable indeed, consequently the losses which arise from time to time by reason of the inevitable shrinkage in value of these more or less fixed assets call for something more than casual treatment in the books of account of each individual building business. The decrease in value may be the result of actual physical deterioration, or it may be a functional depreciation caused by recent developments in science, invention, or labour-saving which render a particular asset, or section of engineering equipment, obsolete for the purpose for which it was originally intended. But whatever the cause of the depreciation may be, it is of the utmost importance that the decrease in value during the period covered by the builder's profit and loss account should be correctly recorded in the financial books, and that an adequate charge should be made under this heading before the balance of profit is withdrawn from the business for private purposes, or shared between the partners, or distributed in the form of dividends. First or original payments made in the acquisition of profit-earning assets

should be regarded as the cost for the period during which service is to be rendered, and in the case of fixed assets this service period usually means several years, each of which should bear its proper share of the cost. In any case, to provide for depreciation on a fairly generous scale during periods of trade activity, while ignoring depreciation in times of trade depression, is an extremely unsound policy to pursue, from both the financial and the accounting points of view.

Is Plant Adequate ?

Apart from the two main causes of asset depreciation, viz. wear and tear, and obsolescence, a vital factor in the computation of the annual or periodical charge is the adequacy or otherwise of the existing equipment. Building and constructional enterprises are constantly reaching that stage when the productive assets are no longer capable of maintaining the expected degree of efficiency, necessitating the acquisition of new and more productive units, and a somewhat ruthless scrapping of the old equipment. Certain machines, instruments, etc., are often scrapped long before they have lost their market value, while on the other hand the constant replacement of worn-out parts, or regular repairing or overhauling, may enable equipment to serve in a perfectly satisfactory manner over a very long period. The continuity of operations conducted by many building and engineering concerns depends to a very large extent on the nature of the facilities and appliances available for carrying out urgent repairs, also on the quantity of spare parts and attachments carried.

Four Methods of Allowing for Depreciation

Although the essential requirement in this important matter of depreciation is that the builder's annual or periodical profit and loss account should be debited with the shrinkage in value of all wasting assets and building equipment, the debiting should be effected in the most equitable manner as between one working period and another. There are several ways of doing this, the four principal methods being enumerated below :—

Method 1.—The periodical profit and loss account may be charged with an equal proportion of the first or original cost of acquiring and installing the asset, or group of assets, so that at the end of the service life—known or estimated—the value as standing in the builder's books of account will be reduced to nil, or to a purely nominal figure.

Method 2.—A definite rate per cent. per annum may be deducted at balancing time from the gradually diminishing book value of the equipment, so that at the termination of a certain period the asset account will show a balance representing the actual value.

Method 3.—A section of plant or equipment may be subjected to a revaluation on the part of a building-trade expert, and the decrease in value, if any, transferred against the current year's profits in one amount.

Method 4.—The final account may be debited with such an amount that, after interest on the amount of unrecovered investment has been debited to the asset account each year, the book value of the asset will be reduced to nil at the end of a definite period, or will represent a purely realisable or break-up value.

Checking Accuracy of Books by Means of " Trial Balance "

Before attempting to ascertain the amount of gross profit made during the year or other accounting period, and before drafting the final profit and loss account and balance-sheet, the clerical accuracy of the book records will have to be verified by drawing up what is known as a " trial balance," consisting of a summary of all debit and credit balances outstanding at the stocktaking date. From the figures enumerated on the trial balance the final accounts will be made up, consequently it is of the utmost importance that all charges relating to the period under review should be adequately provided for.

The fact that for every debit entry made in one book or account, there is, or should be, a corresponding credit entry in another book or account, will enable the builder to prove the correctness of the book-keeping work, for as the total of the debit items recorded in the complete set of books must exactly equal the total of the credit items, it follows that the total of the debit balances of the various ledger accounts will agree with the total credit balances.

When the items recorded in the day book, cash book, purchases book, and the other subsidiary books, or books of original entry, have been posted to their respective ledger accounts, the monthly or other periodical totals can be transferred, the totals in the day book being entered on the credit side of sales account, the total in the purchases book to the debit side of purchases account, and so on. If an ordinary three-column cash book is in use, the monthly totals of the " discounts " column on the debit side—representing discounts allowed by the builder—should be transferred to the debit side of a discounts account opened in the nominal or expenses ledger, while the totals of the " discounts " column on the credit side of the cash book—representing discounts obtained by the builder—will be transferred to the credit side of the same account.

Attention can then be directed to the various management and working expenses accounts kept in the nominal ledger. Each of these accounts should be balanced and ruled off and the balance brought down on the debit side, and the same applies to the property and asset accounts kept in the private ledger. The bank account will be made up of totals transferred from the debit and credit bank columns of the cash book, and if this account shows a debit balance the amount will represent an asset, but if the amount shows a credit balance, the amount will represent a liability. The difference between the two " cash " columns of the cash book will, of course, represent the amount of cash in hand, and this figure should be

reconciled with the actual contents of the cash-box. As soon as all the accounts have been balanced, a list of balances can be made out, this summary constituting the trial balance, from which the final accounts and balance-sheet will be prepared. The following is a specimen trial balance :

SPECIMEN TRIAL BALANCE

	Dr.			*Cr.*		
	£	*s.*	*d.*	£	*s.*	*d.*
Cash	65	17	6			
Bank				3,221	15	5
Capital account				14,090	0	0
Drawings account	208	0	0			
Freehold buildings	2,500	0	0			
Fixed plant	1,930	0	0			
Loose tools	187	10	0			
Dies and special tools	120	0	0			
Motor transport	1,650	0	0			
Furniture, fixtures, and fittings	110	15	0			
Stock	14,186	11	3			
Purchases	17,115	16	7			
Returns outwards and allowances				216	17	2
Sales and charges				29,419	3	8
Returns inwards and allowances	105	6	4			
Discounts account				24	19	11
Grinding- and polishing-machines	127	15	6			
Rates and taxes	184	3	3			
Gas, water, and electricity	131	9	9			
Travelling expenses and commissions	81	14	1			
Repairs to property	63	17	2			
Wages (productive and unproductive)	5,059	8	7			
Carriage and cartage	82	11	5			
Postages and stationery	43	18	7			
Bad debts	22	11	6			
Sundry trade expenses	191	15	5			
Sales ledger balances	4,817	11	11			
Purchases ledger balances				2,013	17	8
	£48,986	13	10	£48,986	13	10

Drafting Balance-sheet, Trading, and Profit and Loss Accounts

Providing no errors have been made in any of the postings or additions during the accounting period, the two totals of the trial balance will agree, and the trading account, profit and loss account, and the balance-sheet may be drafted. It should be observed that the stock figure, as shown on the trial balance, represents the value of the stock on hand at the beginning of the year, corresponding with the debit balance on the stock account ; the value of the stock on hand at the end of the period is in the nature of an adjustment entry brought into the trading account for the purpose of ascertaining the balance of gross profit. Presuming the value of the closing stock to be £11,095 17*s.* 3*d.* ; that depreciation at the rate of 10 per cent. is to be written off the book value of the fixed plant and motor transport ; that 5 per cent. is to be written off loose tools and furniture, fixtures and fittings ; and that sundry trade expenses amounting

to £75 10*s.* 6*d.* have accrued at the balancing date (in addition to expenses actually recorded in the books), the final accounts and balance-sheet would appear in the following form :—

Dr. TRADING ACCOUNT *Cr.*

	£	*s.*	*d.*		£	*s.*	*d.*
To stock on hand as at beginning	14,186	11	3	*By* Sales and charges £29,419 3 8			
,, Purchases £17,115 16 7				*Less* returns, etc. 105 6 4			
Less returns, etc. 216 17 2					29,313	17	4
	16,898	19	5	,, Stock on hand as at end	11,095	17	3
,, Balance, being gross profit transferred to profit and loss account	9,324	3	11				
	£40,409	14	7		£40,409	14	7

Dr. PROFIT AND LOSS ACCOUNT *Cr.*

	£	*s.*	*d.*		£	*s.*	*d.*
To Rates and Taxes	184	3	3	*By* Gross profit from trading account	9,324	3	11
,, Gas, water, and electricity	131	9	9	,, Discounts	24	19	11
,, Travelling expenses and commissions	81	14	1				
,, Property repairs	63	17	2				
,, Productive and unproductive wages	5,059	8	7				
,, Carriage and cartage	82	11	5				
,, Postages and stationery	43	18	7				
,, Bad debts	22	11	6				
,, Sundry trade expenses	267	5	11				
,, Depreciation, viz. :—							
Fixed plant 10%	193	0	0				
Motor transport 10%	165	0	0				
Loose tools 5%	9	7	6				
Furniture, fixtures, etc. 5%	5	10	9				
,, Balance, being net profit	3,039	5	4				
	£9,349	3	10		£9,349	3	10

BALANCE-SHEET

Liabilities	£	*s.*	*d.*	*Assets*	£	*s.*	*d.*
Sundry creditors	2,013	17	8	Freehold buildings	2,500	0	0
Amount due to bank	3,221	15	5	Fixed plant £1,930 0 0			
Accrued expenses	75	10	6	*Less* 10% depreciation 193 0 0	1,737	0	0
Capital account, viz :—							
Balance at end of last period £14,090 0 0				Motor transport 1,650 0 0			
Less drawings 208 0 0				*Less* 10% depreciation 165 0 0	1,485	0	0
13,882 0 0							
				Loose Tools 187 10 0			
Add net profit for the year 3,039 5 4				*Less* 5% depreciation 9 7 6	178	2	6
	16,921	5	4				
Carried forward	£22,232	8	11	*Carried forward*	£5,900	2	6

	£	s.	d.		£	s.	d.
Brought forward	22,232	8	11	*Brought forward*	5,900	2	6
				Furniture, fixtures, and fittings . . 110 15 0			
				Less 5% depreciation 5 10 9			
					105	4	3
				Dies and special tools . .	120	0	0
				Grinding- and polishing-machines	127	15	6
				Stock on hand . . .	11,095	17	3
				Sundry debtors . . .	4,817	11	11
				Cash in hand . . .	65	17	6
	£22,232	8	11		£22,232	8	11

Dealing with Profit

The amounts charged against the profits under the heading of depreciation would have to be credited to the particular asset accounts, all the deductions being shown on the balance-sheet. In the case of a partnership between two or more builders, the balance of net profit shown in the audited profit and loss account would be shared in accordance with the provisions of the partnership deeds or agreements, each partner's capital or current account being credited with the proper proportion ; but if the business has been converted into a limited liability company, the balance of net profit should be transferred to the credit side of a special appropriation account, against which would be debited the dividends actually distributed, the sums transferred to reserve, and any other appropriations, the balance (if any) being carried forward to the next account. In the case of the builder carrying on business on his own account, the balance of net profit would be merged with his capital account.

Tax on Profit

Although the balance of net profit shown in the builder's final profit and loss account will represent the amount of profit actually realised, this figure will not be accepted by the taxation authorities when computing the Schedule " D " income-tax liability. To determine the profit for income-tax purposes, a special account will have to be prepared, incorporating the items not allowed as statutory deductions.

Problems Arising with Partnerships

In the case of the partnership of two or more builders, a number of problems will arise at the close of the firm's financial year, or other accounting period, that do not arise when a business is being carried on by the proprietor on his own account. It will be necessary, for example, to decide quite definitely the form in which the partners' salaries are to be shown in the final accounts, while the methods of recording each partner's

share of profits, and any interest on capital invested, will automatically come up for consideration.

Generally speaking, where one or more of the partners is paid a certain salary in consideration of whole-time service, the amount of such salary applicable to the period under review is posted from the cash book to the debit side of the salaries account, the final balance of which will be transferred to the debit side of the profit and loss account at the stocktaking date. The same procedure is adopted in the case of the junior partner with little or no capital invested in the business, although, of course, for purposes of income-tax, nothing can be withdrawn from the business by any partner except as an appropriation of profits actually realised. If the salary is not paid out in cash, the amount may be credited either to the partner's current account, or to his capital account, in accordance with an agreement, a similar amount being debited to the firm's salaries account.

Sometimes the amount of each partner's capital is definitely determined by deed or other partnership agreement, but as a rule this is not so. If the amount of capital has been fixed, the balance of the capital accounts should remain at the same figures for the duration of the partnership, which means that the salary, share of profits, and interest on capital due to each partner will have to be recorded in a separate drawings or current account kept in the private ledger. The amount shown to the credit of each partner may then be withdrawn from the business, as and when required, or retained as additional working capital by means of a transfer to the partner's capital account.

Interest on Capital

On the question of interest on capital there is considerable difference of opinion in the building trade. While some builders make a practice of charging interest at a fixed rate per cent. per annum on the amount of capital which they have invested, others consider it advisable to ignore interest on capital altogether. In point of fact, it is only in those instances where the amount of capital invested by the partners is in precisely the same proportion as their shares of profits that interest can be ignored without prejudicing the rights of any partner. For example, if A and B are partners in a building enterprise, A's capital being £3,000, and B's capital £1,500, and it is agreed to share profits in the same ratio as each partner's capital bears to the total capital of £4,500—viz. A two-thirds, and B one-third—the balance of the capital accounts would be the same, whether or not interest on capital were ignored.

Separate Job or Contract Accounts

The builder who undertakes to perform certain work or to render definite services at a stipulated figure, will find it advisable to keep separate job or contract accounts for the purpose of ascertaining the precise amount of profit realised in each case, or the extent of the loss sustained.

These accounts should be debited with the cost prices of all bricks, blocks, stone, tiles, materials, and stores purchased in connection with the operations, also the carriage and cartage expenses which have been incurred up to the arrival of the goods, etc., at the spot where they are required, and an adequate sum representing wages paid out to persons engaged on the work. An amount should also be debited to each account to cover the depreciation of lifting-gear, scaffolds, ladders, cranes, winches, hoisting-chains, etc., and for the upkeep and maintenance of grinding- and polishing-machines, paint sprayers, scaffold brackets, and so forth. On the credit side of each account should appear the various sums received during the period of the contract, and at balancing time an entry will have to be made representing the balance of the contract price outstanding, otherwise the margin of profit cannot be determined with any degree of accuracy.

As soon as a contract has been completed in accordance with an agreement, the difference between the debit total and the credit total of the particular contract account may be brought down as a revenue item to be transferred at the stocktaking date to the periodical trading or profit and loss account. In the case of contracts still on hand at balancing time, the balances of the accounts should be treated as assets or as liabilities, according to whether they are debit or credit balances, and included on the balance-sheet. Any balance of contract price outstanding on the completion of the work should be transferred direct to the debtor's personal account, and the following is a specimen account indicating the method of tabulation :—

Dr. CONTRACT NO. 26 (WOKING) *Cr.*

		£	s.	d.			£	s.	d.
Aug. 31	*To* Balance c/d.	189	18	7	Sept. 1	*By* Cheque	150	0	0
Sept. 2	,, Insulation boards	3	6	8	,, 11	,, Balance of contract price transferred to sales ledger	150	0	0
,, 2	,, Rubbing bricks	5	2	6					
,, 3	,, Doors	3	17	6					
,, 3	,, Shutters	4	4	0					
,, 3	,, Tile surrounds	1	8	9					
,, 4	,, Timber	1	15	3					
,, 4	,, Cement		14	9					
,, 4	,, Wages	13	13	3					
,, 7	,, Paint, enamel, etc.		15	5					
,, 7	,, Distemper	1	2	4					
,, 9	,, Glues and varnishes		15	9					
,, 9	,, Chemicals		11	7					
,, 11	,, Wages	12	19	3					
,, 11	,, Depreciation	25	0	0					
,, 11	,, Sundries	4	10	6					
		269	16	1					
,, 30	,, Balance, being profit carried down	30	3	11					
		£300	0	0			£300	0	0
					Sept. 30	*By* Balance c/d	£30	3	11

An Alternative Method of Dealing with Contract Accounts

An alternative method of keeping such accounts consists of recording all amounts of cash received on the credit side of the account of the person, firm, or company with whom the contract was entered into, this personal account being debited on completion of the work with the difference between the contract price and the cost and expenses of performing the work. Wages which do not directly increase the cost of the job or operation should not be debited to the contract account, although the remuneration paid to clerks and others who have been exclusively engaged on the work is a direct charge. It should never be forgotten that the mere fact that a contract has been entered into does not necessitate any entry being made in the books of account, but directly any goods, materials, or stores are purchased or taken from stock with the object of proceeding with the work, the contract account should be opened and debited with the cost, a corresponding credit entry being made in the goods or sales account.

Problems of Joint Accounts

It often happens that two or more builders will undertake jointly to obtain the necessary materials or stores for use in connection with certain work, or to purchase goods for sale at a profit to be shared between them on an agreed basis. In such cases each builder should keep special joint accounts, each account being debited with the invoiced cost of the goods, etc., acquired. If any portion of the material is supplied on joint account direct from the builder's own stock, an entry will be made in the sales book, or day book, in the usual way, the amount being posted direct to the joint account, while all expenses incurred will be recorded on the credit side of the general cash book, or in the cash payments book, as the case may be, and debited to the account either individually or in total form. Expenses accrued at balancing time, but not actually met, should be charged against the particular joint account as a reserve, the amount being brought down as the opening item on the credit side for the next period, and included among the liabilities when drawing up the balance-sheet. Alternatively, the accrued expenses may be posted from the debit side of the joint account to the credit side of the creditor's account, but generally speaking the former method is the more satisfactory. The receipt of a cheque or other remittance from a partner in such ventures will necessitate a credit entry being made in that partner's personal account.

Example of Joint Account

When goods are bought on joint account, the prices charged to customers will be debited to the respective accounts kept in the sales or customers ledger, these amounts being shown on the credit side of the joint account. Sometimes the builder will be entitled to a commission, the

amount of such commission being charged against joint account and credited to commission account, the final balance of which will be transferred to profit and loss. As soon as all the goods, materials, or stores included in the venture have been issued out or sold, the other parties may be credited with their share, the remaining balance being treated as a revenue item. An example of a joint account, closed as at August 31st, is reproduced below :—

Dr. JOINT (SANITARY GOODS) ACCOUNT WITH W. J. BROWN *Cr.*

			£	*s.*	*d.*				£	*s.*	*d.*
July 31		Forward . .	371	14	5	July 31		Forward . .	410	16	8
Aug. 8	*To*	Goods . .	14	2	9	Aug. 6	*By*	Contract 13 .	52	16	3
,, 11	,,	Carriage .		16	8	,, 19	,,	I. Deacon . .	11	7	2
,, 12	,,	Outlet connections	3	3	0	,, 19	,,	Cash Sales .	5	8	6
,, 15	,,	Goods . .	11	12	4						
,, 31	,,	Sundry expenses	9	4	3						
,, 31	,,	Commission .	12	10	6						
,, 31	,,	W. J. Brown .	33	12	4						
,, 31	,,	Balance, being profit transferred to profit and loss .	23	12	4						
			£480	8	7				£480	8	7

QUANTITY SURVEYING

QUANTITY surveying may be described as the accountancy of building, or the science of measuring and valuing building works. The quantity surveyor must have a detailed knowledge of building construction, the value of materials and labour, and be expert in the recognised methods of measuring, describing, and classifying the different items contained in a building.

The quantity surveyor acts on behalf of the party for whom the building is being erected, and who is generally known as the *building owner*, and by means of *bills of quantities* procures from a number of contractors definite estimates of the cost of the building, and the length of time required to complete the erection. The lowest or most suitable tender is then accepted, the contract signed, and building commences.

It is usual for buildings to be paid for during the progress of the contract according to the value of the work completed from time to time, less a percentage which is retained from each payment. In the event of the contract being satisfactorily fulfilled and without variation, the full amount of the retention money is then paid. When occasion arises for these payments on account, the quantity surveyor meets the contractor or his representative and agrees on the value of the work executed to date and the amount of materials on the site. From the figure arrived at, the amount of retention money is deducted, and a certificate for payment is then handed to the architect, and he, being satisfied that the contract is being properly executed, authorises payment.

Certificate for Payment

The following is an example of such a certificate, and is a summary of the figures of the valuation :—

CERTIFICATE NO. 3, 31ST MARCH, 1937

		£	*s.*	*d.*
To value of work executed to 31st March, 1937 . .		5,000	0	0
To value of materials on site		500	0	0
		£5,500	0	0
Less amounts previously certified :—				
Certificate No. 1	£1,000 0 0			
,, No. 2	1,500 0 0			
		2,500	0	0
		£3,000	0	0
Less amount of retention, 10 per cent. . . .		300	0	0
		£2,700	0	0

Therefore the amount due to the contractor would be £2,700. It should be noted that the deductions for previous payments made are not the net amounts actually paid, but include the amounts of retention.

Alterations to Plan

Buildings are rarely erected without any alteration to the original plans or specified materials, and the contract contains a clause that all authorised additions to and omissions from the contract are to be adjusted at rates *pro rata* to those contained in the bills of quantities. Any such adjustments are valued by the quantity surveyor and agreed to by the contractor, and either added to, or omitted from, the contract figure. Variations having been settled, a final amount is then prepared, setting forth all additions and omissions as measured and agreed to, the balance between the two showing either an increase or decrease on the amount of the contract.

The method of dealing with variations and preparing final accounts will be dealt with under a separate heading.

Having briefly described the three main functions of a quantity surveyor in connection with the erection and completion of a building, each of these stages will now be dealt with separately.

BILLS OF QUANTITIES

A bill of quantities is a document containing full descriptions of all work required to be done, and measurements of all materials as actually fixed in the building. It also contains a reference to the conditions of the contract, and any special conditions relating to the site or the manner of construction, so that the contractor has a full idea of the nature and amount of work required.

The contents of a bill of quantities are subdivided into separate bills, and the totals of each are collected together in a summary which, being added up, should form the amount of the contractor's estimate for the complete work.

The first bill, or subdivision, is entitled "preliminaries," and should contain a general description of the nature of the proposed work, a reference to the conditions of contract (usually a separate document), and any other item of a special character likely to affect the cost of the building. The remaining bills give the total measurements and descriptions of the work contained in the building, with all items of the same trade collected together and appearing under their trade headings (i.e. excavator, concretor, bricklayer, etc.).

The paper on which these bills are printed is divided into columns, those on the left and in the centre being filled in by the quantity surveyor and giving the amount and description, respectively, of the work required; the columns on the right are filled in by the contractor who is tendering, and in these he quotes the rate at which he will execute the particular

work referred to, and on the extreme right the total amount derived from the item. The following is an example of the usual procedure :—

Yards	*Feet*				*Rate*	£	*s.*	*d.*
100	—	--	Cube	Concrete (1 : 6) in foundations	16/–	80	0	0
20	—	--	Super	Concrete (1 : 2 : 4) 6 in. thick spread and levelled in floors and finished to receive pavings	2/6	2	10	0

As will be readily seen, the preparation of a bill of quantities involves a great deal of work and is a collection of all the items contained in the proposed building reduced to the recognised standards of measurement, fully described, and classified under their respective trade headings.

There are two distinct operations in producing the bill of quantities ; the first of these is the measurement of the quantities from the drawings, and this is generally known as " taking off " the quantities.

In the second operation the dimensions are worked out or " squared," and all the items are collected together on an abstract under their trades, and reduced to the required factor (i.e. yards, feet, etc.), from which the final document, the bill of quantities, is then prepared. This second operation is known as " working up " the dimensions. Although greater skill is required in taking off dimensions, and is the work of the surveyor, the working up also requires considerable skill and experience in order to produce a proper bill. Each of the two operations will now be separately dealt with.

Taking Off the Measurements

There are several methods or systems of taking off quantities, and each has points in its favour, but whichever one is adopted it is essential to adhere rigidly to a system, in order to reduce possibility of error to a minimum.

It is not proposed to discuss the various methods used, and that described herein is the one in general use, especially in London.

The general method is to measure first the carcass of the building, and then all finishings ; and finally plumbing, drains, and any other services. The following is a brief list showing the usual order of taking off :—

Preliminaries
Foundations
Brickwork and partitions } *Carcass*
Roofs
Floors

Floor finishings
Skirtings
Picture rails, etc.
Plastering, etc. } *Finishings*
Doors
Windows
Fires
Sanitary fittings, waste pipes, etc.
Cold-water supply
Hot-water supply
Drains
External work, i.e. fences, gates, paths, etc.

The method of measurement of each of the foregoing items will be described later under separate headings.

In the past there has been much disagreement between surveyors and builders regarding measurement of building works, until finally the Chartered Surveyors Institute and the leading building organisations agreed upon methods to be adopted, and these have been compiled in a volume entitled *The Standard Method of Measurement of Building Works*. This method is now generally used, and the examples given herein are in accordance with it.

Before proceeding to describe the actual taking off the quantities, it should be observed that the dimensions form the basis of the bills of quantities, and should be set forth as neatly as possible, with sufficient notes and directions showing how the figures are arrived at to enable any practised person to understand them, so that in the event of any omissions having to be made from the original contract, it is an easy matter to extract the figures and items required.

Method of Writing down Dimensions

The manner of writing down the dimensions can be seen from the examples which follow later, but the following example will explain the general system :—

(A)	(B)	(C)	(D)
			Note.—Bedroom doors = 4 Living-room = 2 6
6/	2 8 6 8		2-in. door four-panel, moulded both sides and
		106 8	Knot, prime, stop, and paint 4 coats on both sides of doors ÷ 8.

The dimension paper is divided into columns as shown. In column B the dimensions of the door are written, and in D the description. In this particular instance there was a total number of six doors of the same kind, therefore the six is put down in column A, the " times-ing " column. The figure resulting from the working out of the dimensions appears in column C. In the description column a note will be seen indicating which doors are being measured. The paint will be twice the same area as the doors, and to avoid writing the figures again the description is added on as " paint, etc., on both sides ÷ 8," which means that the abstractor must put twice 106 ft. 8 in. on the painting abstract. To allow for the extra paint in and out of mouldings and to the edges of doors, instead of dividing by 9 to reduce the area to square yards, it is usual to divide by 8.

Dimensions should always be quoted in the following order : length, breadth, and width or depth. Adherence to this rule helps to make the taking off easier to follow in the event of variations.

For the sake of clearness all words have been written in full in the examples of taking off shown in this article, but there are numerous abbreviations in general use. Before commencing to take off the quantities it is a good plan to make a list of the items which will have to be measured (i.e. foundations, etc., brickwork, roofs, finishings, floors, etc.), and as they are completed, to strike them off the list.

The general principle of taking off is to take over-all measurements of such items as brickwork, facings, plastering, roof slating, etc., and to make any deductions for openings, such as doors, windows, roof lights, etc., at the same time as the latter items are measured. Should the original plans be altered and, for example, a window be omitted, the whole of the items connected with the window can be found in one group, and the necessary adjustment is easily made.

Preliminaries

The preliminaries bill should contain brief descriptions of the position, means of access to the site, and character of the proposed building.

The conditions of contract, which usually form a separate document, should be referred to so as to enable the contractor to include for any special sums of money which he may consider that the conditions warrant.

A clause should also be inserted requiring the contractor to visit the site and form his own opinion of the nature of the site and proposed work, to enable him to provide everything necessary for the proper execution and completion of the contract. At the same time mention should be made of any known obstacles or conditions with which he will have to contend. It is also usual to make reference to the terms of payment for the contract.

EXCAVATOR AND CONCRETOR

Excavation

It is usual to take an item for removing vegetable matter over the whole surface of the site for a depth of from 6 in. to 12 in., and this is measured in yards superficial. In addition, it may be necessary to excavate over the whole or parts of the site to remove mounds of earth or to reduce the surface to lower levels, and where such digging is required, and exceeds 12 in. but does not exceed 5 ft. in depth, it is measured in yards cube, and described as " Excavate over the surface not exceeding 5 ft. deep to reduce levels."

All cubic excavation, whether in bulk or to trenches, is measured and described separately in stages of 5 ft. in depth. Thus, where the bulk excavation over the site was 6 ft. 6 in. deep, the cubic content of the first 5 ft. in depth would be described as " Excavation not exceeding 5 ft. deep," and the cube of the remaining 1 ft. 6 in. in depth would be " excavation exceeding 5 ft. but not exceeding 10 ft. deep."

It is obvious that when a man digs below a certain depth he cannot throw out the excavated material in one movement, but has to do so in stages. The deeper the excavation the more expensive it becomes, therefore each stage of 5 ft. in depth is separated.

Planking and strutting should be measured in feet super to all vertical faces of excavation, and separately described as being to trenches or around pier holes, etc., in stages of 5 ft. in depth, or to sides of basement excavation, etc., and stating the general depth.

" Returning, filling in, and ramming excavated material around walls, etc.," should be taken in yards cube.

Surplus material arising from excavations must be measured in yards cube as " carted away from site," or any other manner of disposal described.

It should be clearly stated that prices for excavation are to include " for keeping free from water by pumping, etc.," and if it is known that excessive water will be met with the bill should contain a provisional number of hours for " pumping, including use of pump and power."

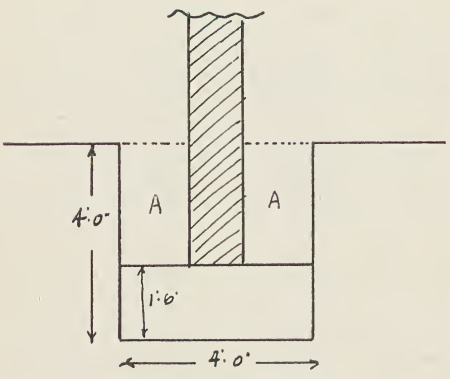


Fig. 1.—SECTION THROUGH FOUNDATIONS TO 18-IN. BRICK WALL

Scale : $\frac{1}{4}$ *in.* = 1 *ft.*

Concrete in foundations should be measured in yards cube, and if under 12 in. in thickness this should be stated.

Concrete in floors is measured in yards super, and the thickness stated. Precast concrete lintels should be measured in feet run, the size stated, and the reinforcement

and shuttering included in the same description. The total number of lintels should also be given.

Example of Measuring Foundations

Fig. 1 is a section through foundations to an 18-in. brick wall, and the total length will be considered as 40 ft.

	40 0 4 0 4 0		Excavate surface trench not exceeding 5 ft. deep and throw out and return and fill in and ram excavated material around walls.
2/	40 0 4 0		Planking and strutting to sides of surface trenches not exceeding 5 ft. deep. (Both sides measured.)
	40 0 4 0 1 6		Portland cement concrete (1 : 6) in foundations and *Deduct* return, fill, and ram and *Add* cart away surplus excavation. Depth . . . 4 0 *Less* . . . 1 6 2 6
	40 0 1 6 2 6		*Deduct* return, fill, and ram and *Add* cart away surplus excavation.

The first dimension is the total length of the foundations and the extreme width and depth of the digging, the whole being described as "Returned and filled." The cube of the space occupied by the concrete and brickwork is deducted later, and what is left is the net amount of "return, fill in, etc." (as marked A on the sketch). The other dimensions are self-explanatory, and the brickwork is measured later.

BRICKLAYER

Brickwork

Brickwork must be given in the bill as "rods superficial," a rod of brickwork being 272 sq. ft. of brickwork one-and-a-half brick (or "$1\frac{1}{2}$ B," as quoted in the dimensions) in thickness. Brickwork should be taken off in thicknesses as it occurs, collected together in the abstract, and then converted to the standard $1\frac{1}{2}$ B thickness.

When brickwork is built off girders (with no brickwork below), or raised on existing walls, it should be included with the ordinary brickwork, but an additional item for scaffolding given in feet run should be measured, stating the height at which the work commences. This is not required when the building is steel-framed. Preparing the tops of old

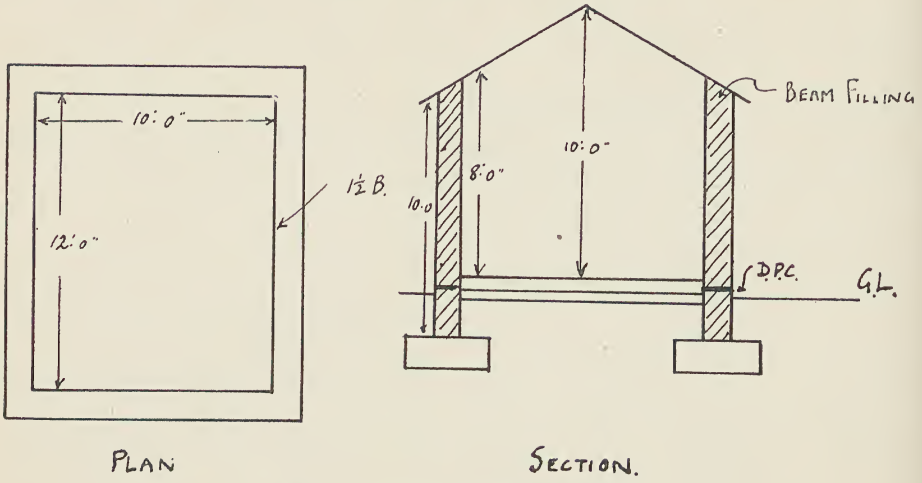


Fig. 2.—TAKING OFF BRICKWORK

walls for raising and flushing up with cement mortar to cover rivet heads on top of girders should also be taken in feet super.

Half-brick walls should be given separately in feet or yards superficial, also one-brick walls faced and finished fair on both sides.

Finishing and Pointing

Finishing the face of brickwork fair, and pointing, should be measured as " Extra for fair face, etc.," in yards superficial.

All special brick facings and pointing should be measured in feet superficial, and described as " Extra only over the ordinary brickwork for facings, etc." All internal and external facings should be separately described.

Rough cutting, including waste, should be measured in feet superficial. Fair cuttings are measured in feet run, and when rough cutting has also been measured behind the fair cutting, a deduction should be made from the rough cutting of the length of the fair cutting by a depth of 4½ in.

" Labour to plumbing external angles " should be measured in feet run to all external angles, wherever the brickwork is faced or finished fair.

Whenever beam filling occurs it is measured in feet run, stating the wall thickness and including cutting and waste, the actual brickwork being included with the general brickwork.

An Example

The following example will explain most of the foregoing points (see Fig. 2).

It will be seen, from the foregoing sketch and examples of taking off, that the dimensions of the brickwork were obtained from the total length of the four walls by the average height of the side walls, and the

Brickwork (from top of foundations to roof) :—

				2/10	0	20 0
				2/12	0	24 0
			Angles	4/ 1	1½	4 6
						48 6
	48	6				
	10	6				
2/			1½ B in cement			
½/	10	0				10 0
	2	0				8 0
						2 0
						12 0
				2/1	1½	2 3
						14 3
2/	14	3	Labour only, beam filling on top of 1½ B wall including raking, cutting, and waste to under side of sloping roof.			
2/			(*Gables*)			
2/	7	0	Rough cutting and waste on brickwork to gables.			
	1	2				
			DAMP-PROOF COURSE			
	48	6	Damp-proof course in brick walls formed of two courses of slates, etc. etc.			
	1	2				
			EXTERNAL FACINGS			

					Height	
2/	10	0	20	0		
2/	12	0	24	0	10	0
4/	2/1	1½	9	0	*less* 1	9
			53	0	8	3
					add	6 (below ground)
					8	9

53	0	Extra only over ordinary brickwork for facing with picked stock facings, and weather pointing (as described).	
8	9		
2/		(*Gables*)	
½/	12	3	10 0
	3	0	2/1 1½ 2 3
			12 3
4/	8	9	Labour plumbing external angles of brickwork.
2/			
2/	7	0	Fair raking, cutting, and waste in picked stock facings.
2/			
2/	7	0	*Deduct* rough cutting, and waste on brickwork to gables.
		4½	

two triangular-shaped gables were then added (the area of the triangles being half of the length of the base times the height). The facings were measured similarly, except that the total external length of the walls was taken. It should be noted that all openings for windows, doors, etc., have been ignored, any deductions being made when the windows and doors are measured.

DRAINS

Stoneware and iron drains should be fully described ; the method of jointing stated, and given in feet run. Iron drains should be measured for the net length as laid, but stoneware drains in lengths divisible by two. In each case such items as bends, junctions, taper pieces, etc., should be enumerated and described as " Extra only over the piping including extra joints." Connections of iron drains to manholes should be enumerated as " Cutting and waste on pipe."

Excavation

Excavation for drain trenches should be given in feet run, and the average depth stated in stages of 5 ft., and should be described in the following manner : " Excavate trench for 4-in. drain, average 3 ft. 6 in. deep, and not exceeding 5 ft. deep, throw out, return, fill in, and ram ; and cart away any surplus including all planking and strutting required."

All fittings, such as gullies, intercepting traps, etc., should be enumerated, and include concrete foundations and joints to drain in the description.

Concrete beds under drain pipes or in encasing should be given in feet run, the width and thickness being stated.

Work in Manholes

Work in manholes should be kept separate, and the total number of them given. They should be measured in detail (i.e. excavation, brickwork, concrete foundations, cover, etc. etc.). The channels should be described and enumerated, the different types being kept separate. The number of holes through the sides of manholes for drain pipes should be taken, and where step irons will be required, the number given.

Connections to Sewers

The number of connections of the drains to the public sewers in the road (or otherwise) must be given, and it is usual for this item to cover all the work in connection, including laying on the drain to within the boundary of the site, taking up road and footways, relaying and making good, all watching, protections, and lighting, giving all notices to the local authority, and for paying all their fees and charges. An approximate length from the sewer to the boundary (or other point described), and the depth of the sewer, should be given when possible.

Finally, an item must be taken to cover the cost of testing the whole of the drainage system to the entire satisfaction of the architect and any other authority concerned. If any special testing methods are to be used, this should be stated.

MASON

Stonework generally must be given in feet cube, with full descriptions of the stone, all labour, the manner of jointing, hoisting, and fixing.

Stone in ashlar facings is given in feet super, and the average width of the beds stated. Small cornices, strings, band courses, window cills, etc., are given in feet run, and all angles, stoolings, etc., enumerated.

When the stone has been measured in feet cube, labour, such as "cutting grooves," must be taken in feet run and the number of stops given.

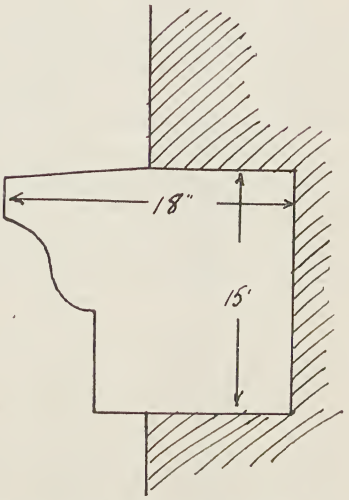


Fig. 3.—EXAMPLE OF MEASURING A STONE CORNICE

Artificial Stone

This is measured in the same manner as ordinary stone, its composition being described. The moulds for making the stone are not measured, but a statement should be inserted in the bill that all prices for the stone are to include all moulds.

Example of Measuring a Stone Cornice

			Portland stone and hoisting and fixing not exceeding 40 ft. above ground.
40	0		In sunk and weathered and sunk and moulded projecting cornice (and jointing, etc., as described).
1	6		
1	3		

The length of the cornice has been taken as 40 ft., the next dimension is the thickness or bed, and the last figure of 1 ft. 3 in. is the depth. All measurements of all stone must be the smallest rectangle from which the stones can be cut. In the foregoing example it has been considered that a full description of the stone, the mortar for jointing, and the manner of fixing has been given in a general preamble preceding the items in the bill.

SLATER

Slating and battens are given in the bill in "squares." A square is equal to 100 sq. ft. or "feet super." The measurements are taken from the net area covered by the slates. No openings (for chimneys, roof lights, etc.) under 4 ft. super must be deducted, but no cuttings or labours are measured around openings where no deductions are made. The slating and battens should be fully described, with the size of the slates, the length of the lap, and how they are to be nailed.

Forming double courses at eaves should be described and measured in feet run. Along the top of slating on each side of ridges, or when abutting against walls, etc., an item of "labour top cutting in slating" is taken in feet run. Where slating abuts against side walls or on each side of chimney stacks, roof lights, etc., "labour cutting slating to square abutments" is given in feet run. "Raking, cutting, and waste on slating" must be measured in feet run wherever this occurs, as on each side of valleys and hips.

Ridge and hip tiles must be described, with all bedding and pointing in mortar, and given in feet run, and all fair ends, mitred junctions, etc., enumerated.

Example of Measuring a Roof

From the following sketch and taking off it can be seen how measurements for slating are taken. The first figure is the extreme length of slating along the eaves by the height up the slope, the whole being multiplied by two for both sides. It will be found that where the slope of the roof is the same all round, as in this example, the measurements as taken will give the correct area of the roof without having to measure the hipped ends separately.

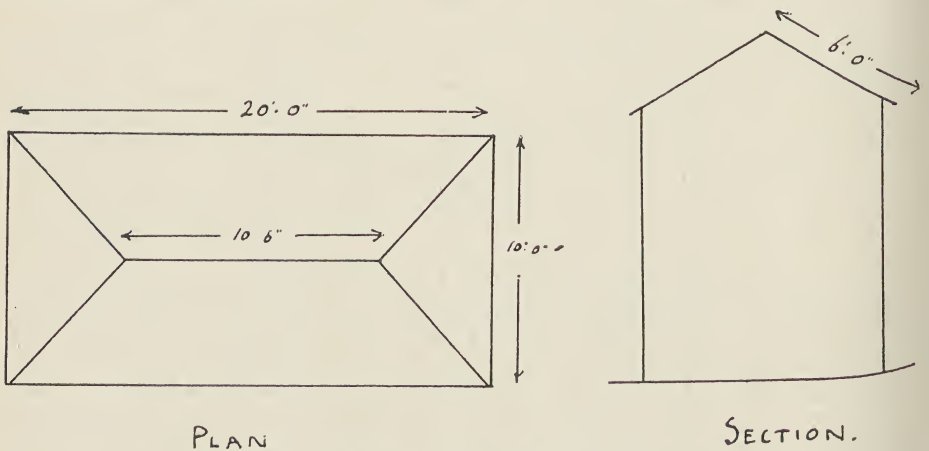


Fig. 4.—EXAMPLE OF MEASURING A ROOF
Scale : $\frac{1}{8}$ *in. to* 1 *ft.*

2/	20 0 6 0		10 in. by 20 in. slating laid to a 3-in. lap, etc. (as described) and $1\frac{3}{4}$-in. by $1\frac{1}{4}$-in. sawn deal battens for ditto.
2/	20 0		Extra for double eaves course to slating and
2/	10 0		Deal splayed tilting fillet.
2/	10 6		Labour top cutting on slating.
4/	10 6		Saddle-back ridge tiles bedded solid in cement mortar and pointed.
	7 6		Ditto, but to hips.
	4		Extra for fair ends to ditto filled in solid.
4/ 2/	2		Extra for mitred intersections of one ridge with two hips.
	7 6		Raking, cutting, and waste on slating to hips (both sides measured) and Ditto on battens (ditto).

CARPENTER

Formwork

Formwork is measured to the actual concrete face with which it is in contact. Formwork to flat soffits of floors and flats should be given in yards superficial, and if it has to be strutted or supported for over 13 ft. in height, this should be stated and separated. Formwork should be given separately and described for whatever purpose it is required, such as walls, floors, beams, columns, etc. All irregular surfaces should be separated and described. Formwork to beams and columns and to small surfaces should be given in feet superficial.

Raking and circular cutting, moulded edges, etc., are all given in feet run.

The descriptions should include for erection, strutting up, and taking down ; and removing when no longer required. If formwork is to be wrought, or if, for any reason, it cannot be removed, but is to be left in, it should be separated and described as such.

Centering

Centering should be measured to the soffits of brick arches and described as flat or circular as required, and where the soffit is over 9 in. wide, given in feet superficial, or if under 9 in. wide, given in feet run, and the width stated.

Centres for bull's-eye openings should be enumerated, and all measure-

ments of the openings quoted. Where it will be necessary temporarily to support overhanging stone cornices, stone arches, window heads, etc., the amounts required should be given in feet run, with a description of what it is required for, and the width of the soffits and the height of the strutting stated.

Timber for Constructional Work

Timber in carpenters' work, such as in roofs, floors, and other constructional work, can be given in feet run, but it is usually given in feet cube with the scantlings (or sizes) stated. The actual sizes as fixed in the building are measured, but in every 20 ft. of length, where timbers are continuous, an additional 6-in. length should be added in for halved joints, and a length equal to twice the depth of the timber for every scarfed joint. The number of dovetailed or scarfed joints should be given, and the size of the timber in which they occur stated.

All timber should be described in the bill as being in plates, floor joists, rafters, partitions, etc. etc. When timber is framed this should be stated, and although the framing is included in the description, the extra timber for tenons, etc., must be added. Wrought timber can either be separated and described, or else an additional item of " labour only to planing the surface " measured as such in feet superficial.

Ridges to roofs must be given in feet run, also hips and valleys, and the description of the two latter items should include for cutting rafters against each side.

Trimming

Wherever floor or ceiling joists or rafters have to be trimmed around openings, all such openings must be enumerated and all sizes given in the following manner : " Labour trimming 4-in. by 2-in. fir rafters to form opening 2 ft. 6 in. by 3 ft. 6 in. for chimney."

All additional labours to timbers, such as boring holes for bolts, etc., sinking heads, and pelleting, etc., should be enumerated. In addition to the actual measurements and descriptions of such items as roof trusses, lantern lights, turrets, etc., the number of such items should be given as, " Hoist only king-post roof truss 20-ft. span and 7 ft. high approximately 30 ft. above ground."

Battening

Counter battening, wall battening, and roof boarding are given in squares, and separately described to flat, vertical, sloping, or to other irregular surfaces. The sizes of battens and the distances at which they are spaced should be quoted. The thickness of roof boarding and the manner of fixing must be given, and the description should include for splayed edges, but raking or circular cutting and waste are measured separately in feet run.

Boarding

Boarding to flat roofs, including firrings to slight falls, is given in squares, but when the firrings exceed 2 in. in the average depth, these must be given separately in feet run and described. If boarding is to be prepared to receive lead, asphalte, or other coverings, this should be stated. Roofing felt is given in yards superficial, and measured over the net surface covered. No extra is measured for the laps in the felt, but the description should state that the measurement is "net," and laps must be allowed for.

Boarding to eaves soffit, where 18 in. wide and over, is given in feet superficial, and all bearers taken separately, but when under 18 in. wide it is given in feet run, and the bearers are included in the description.

Fascias, barge boards, mouldings, etc., are given in feet run, stating the manner of fixing, and all mitred angles, moulded ends, and similar items should be enumerated, and follow the item to which they belong.

Tilting fillets, layer boards to roofs, narrow gutters, rolls for leadwork, floor fillets, herring-bone or other struttings to joists, and all similar items should be given in feet run, and all sizes and the manner of fixing given.

JOINER

The items of the joiner's bill should be grouped together and appear under headings as follows: floors and skirtings; windows; doors; window and door frames; window and door finishings (i.e. linings, architraves, window boards, etc.); dado and picture rails; staircases; fittings (i.e. shelves, cupboards, etc.). In addition, these main groups should be subdivided under headings for the different timber required, such as deal, oak, teak, etc., with all their attendant labours.

It should be clearly stated in the bill whether the sizes given are those as "finished," otherwise an allowance of $\frac{1}{16}$ in. must be added to each wrought face.

All joinery work should include for all nails, screws, and fixing, and the manner of fixing must be properly described, and all rough backings and grounds either included with the items to which they belong or taken separately.

Items of irregular shape, such as semicircular-headed doors and windows, must be given separately and described.

Woodwork in linings, window boards, and similar items not otherwise described, and exceeding 9 in. in width, must be described as being "cross-tongued," unless it is required in a single width, in which case it should be kept separate and billed as such.

Floors

Boarded floors are measured in squares, and wood-block floors in yards superficial. The net area covered is measured, no extra being

allowed for tongues. The flooring and manner of nailing or fixing should be described, and if boarding is required, the width of the boards should be stated. If flooring is to be prepared for staining and polishing, etc., this should be stated. Raking and circular cutting and waste, margins round hearths or mat sinkings, etc., are all measured in feet run. Straight cutting and waste are not measured to boarded floors, but the description of the flooring should state that it is to be allowed for in the price. Where wood-block floors are required, cutting and waste must be measured in feet run around the edges of each area covered. Special borders must also be similarly taken, and where these occur the cutting and waste can be included as follows : " Extra only over $1\frac{1}{4}$-in. wood-block flooring for border (as described), including all cutting and waste on the flooring." Wherever wood floors of any kind have to be cut and fitted around small piers, circular ends of steps, and similar items, these must be enumerated and the size and description given. No deductions are to be made in any wood floors for openings which do not exceed 4 ft. superficial.

Skirtings, Picture Rails, etc.

These and all similar items, such as wood cornices, dado or chair rails, architraves around openings, etc., are given in feet run and fully described, with the manner of fixing, and whether grounds are required. Mitres, cut and fitted ends, moulded ends, etc., must all be enumerated and follow the items to which they belong, but where the wood is deal or any other softwood and the sectional area does not exceed 6 in., it is not necessary to take these, but the description of them must state that these are to be included.

Windows, etc.

Casements, fanlights, borrowed lights, etc., are given in feet superficial, but the number of them must also be stated. The manner of hanging and fitting casements, etc., must be described, together with the number of squares into which they are divided, and the type of bar required. Where sashes and cased frames occur they are measured together in one item in feet superficial and the number stated, giving complete descriptions of the sashes and all sizes of the component parts of the frames and cill. In addition, an item must be taken for hanging the sashes, including sash pulleys, weights, and cords, all being fully described. Any extra labours on the cased frames and sashes not included with the general description must be measured separately.

Doors

Doors can be given in feet superficial, stating the number, or else they can be enumerated and the sizes quoted. In all cases the doors must be separated into their different types, stating the number of panels, and whether moulded or square ; and if the doors are hung to swing or hung folding, etc.

Frames, Linings, etc.

Plain linings, solid frames, mullions, transoms, cills, etc., to doors and windows are to be given in feet run, and although the actual labour of framing or tonguing the angles is contained in the description, the extra length of timber required must be added. In addition, a length of 3 in. for each horn to a frame should be allowed.

Glazing-beads

Beads or fillets for fixing glass in windows, doors, etc., are given in feet run, including the mitres in the description, and if brass cups and screws are required for fixing, this should be stated.

Staircases

These should be measured in detail and kept under a heading in the bill. The treads and risers are measured in feet superficial, the following being an example: "$1\frac{1}{4}$-in. deal cross-tongued treads with rounded nosings, and 1-in. deal risers, all tongued and grooved together and supported on and including strong fir-framed carriages." Where the ends of the treads and risers are housed and wedged to strings, notchings around newels, shaped bottom steps, and similar items not covered by the general description must be enumerated. Strings, handrails, newels, nosings around staircase openings, and similar items must be measured in feet run; and all such items as ramps, mitred angles, housed ends, etc., should be enumerated and follow the particular item to which they belong. The number of balusters required must be given, with full particulars, as following example: "$1\frac{1}{4}$-in. by $1\frac{1}{4}$-in. deal plain balusters 2 ft. 9 in. long, housed on rake at both ends, one end to deal and the other to hardwood."

Generally

All labours, such as grooves, tongued angles, rounded nosings, etc. etc., where additional to any such labours actually included in the general description of a particular item, must be given separately in feet run, and all labours on hardwoods must be distinct from those on softwoods. When lengths of mouldings, fillets, and similar items do not exceed 12 in., they should

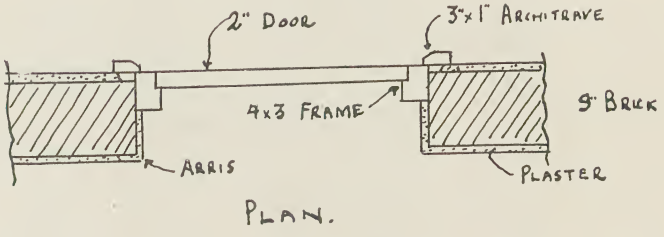


Fig. 5.—Example of measuring doors
Scale: $\frac{1}{2}$ in. to 1 ft.

be enumerated, also all items of joinery, such as backboards to flushing cisterns, brackets, etc., which can be conveniently covered in one description.

Ironmongery

All ironmongery should be taken in the dimensions immediately following the particular item to which it belongs. Where the articles of ironmongery required are not of a stock pattern, a " prime cost " price for each should be quoted. Ironmongery should be described as including all screws and fixing complete, no extra being measured for cutting notchings, mortices, etc.

Example of Measuring Doors

Note.—20 dining-room doors.

20/ — 2 8 / 6 8

2-in. deal, four-panelled, moulded both sides door

and

Knot, prime, stop, and paint four coats in oil colour on *both sides* ÷ 8.

20/ — 1 —

Pair 4-in. brass butts fixed to deal.

20/ — 1 —

Mortice lock and brass furniture prime cost 7*s.* 6*d.* per set, and *add* for profit, packing, carriage, and fixing to deal.

		Frame
		2 8
	2/6 ft. 8 in. .	13 4
(angles)	2/2/3 in. .	1 0
(horns)	2/3 in. .	6
		17 6

20/ — 17 6

4½-in. by 3-in. deal rebated and moulded frame grooved for plaster

and

K.P.S. and (4) *Super by* 10 *in.*

and

Bed door frame in cement mortar.

20/ — 2 —

Galvanised-iron dowels and double mortices in deal.

20/ — 4 —

Galvanised-iron cramps screwed to back of door frame and built into brickwork.

	17 0
2/2/3 in.	1 0
	18 0

20/ — 18 0

3-in. by 1-in. deal chamfered architrave, mitred and fixed to and including rough splayed grounds plugged to walls

and

K.P.S. and (4) on ditto

	2 8	6 8
2/2 in.	4	2
		6 (lintel)
	3 0	7 4

20/	3 0	
	7 4	*Deduct* 1 *B.*
20/	4 0	9-in. by 6-in. concrete lintel reinforced with and including No. 2—½-in. steel rods and all moulds.
20/		
2/	3 0	*Deduct* wall plaster (as described)
	6 10	and
		Deduct twice distemper 3 0
		2/6 10 13 8
		16 8
20/	16 8	Wall plaster 4½ in. wide to reveals, including rounded arris
		and
		Twice distemper super by 5 in.

The foregoing example shows the quantities as taken off for twenty similar doors in a block of flats. The complete quantities for one door are measured first, and then all the items are "timesed" or multiplied by twenty. Only the figures in the dimension columns are abstracted; the figures on the right of the paper are merely calculations showing how the dimensions are obtained, but they should always be shown on the dimensions. It will be seen that the paint should always follow the items where it is required, and the description of the paint on the frame and architrave has been abbreviated in the usual way, but is the same as to the doors. The deductions from brickwork and plaster follow the doors; the plaster is also multiplied by two where the walls are similarly plastered on both sides; and the additional plaster to the reveals formed by the opening is then added.

No skirting has been deducted for the opening, as it is usual to make all deductions at the time of measuring the skirtings, and dados would be similarly treated. These departures from the rule of measuring everything in bulk, and then making deductions for openings following the items to which they belong, simplify the taking-off owing to the varied nature of skirtings and dados occurring in the same building.

FOUNDER AND SMITH

All items in this trade should be classified under headings in the bill as cast iron, wrought iron, steel, etc.

In modern practice, fireplaces, metal windows and doors, and similar items of a specialist nature, have sums of money included in the bill to cover their cost, and the builder has to add to these sums his charges for profit, etc., and for fixing; or where they are fixed by the specialist firm concerned, he adds for his profit, and use of his scaffolding, plant, etc., and, of course, all this must be clearly stated in the bill, together with measurements and descriptions of any work he will have to do, and material he will have to supply in connection with such items.

Steelwork

Steelwork in steel-framed buildings, or where in large quantities, is customarily supplied and fixed by specialist firms, and sums of money to cover these are inserted in the bill and described for such purposes ; and the building contractor has to include for his charges in connection with the work as previously described.

Where steelwork consists of sundry joists and similar items to be supplied and fixed by the builder, these must be measured and the weight calculated and inserted in the bill, keeping separate steelwork hoisted and fixed at different levels. Cut, notched, cleated, and fitted ends, etc., must all be enumerated in addition.

Wrought Iron

Bearing-bars to arches and chimneys are given in the bill in weight, and separately described as such. Railings, gates, balustrades, grilles, or guard bars to windows and similar items should each be separately described, and the weights given as in the following example :—

" 10 cwt.—In wrought iron balustrade 10 ft. long and 3 ft. high consisting of 1-in. square uprights spaced at 6-in. centres, with the top ends countersunk screwed to 2-in. by 1-in. flat rail, including drilling all holes, etc." In addition to the foregoing, any items such as forged and split ends for building in, scroll ends to the rail or forged bends, etc., must be enumerated as extras. Bolts, including heads, nuts, and washers, are given by weight, separated into groups of the same diameter, and the number required must be quoted.

PLASTERER

The materials to be used and the proportions of mixing them must be adequately described. If plaster is to be finished to a required thickness this must be stated, but otherwise, common plastering in two coats is considered as not exceeding $\frac{5}{8}$ in., three-coat work as not exceeding $\frac{7}{8}$ in., and patent plaster in two coats as not exceeding $\frac{1}{2}$ in. thick.

Plastering must be classified as being on brick, concrete (including any hacking to form a key), wood or metal lathing, etc. Ceilings and walls are separated, also plastering to sloping or other irregular surfaces. Wood lathing is included with the plastering, but metal lathing must be given separately.

Plastering to old walls must be separated, and should be described as including any dubbing out to make up irregular surfaces ; raking out joints or other work required to prepare old walls to receive the new plaster must also be measured.

Measurements

Generally, plaster is measured in yards superficial, with the following exceptions : detached portions of plaster not exceeding 1 yd. superficial

must be described as "in small quantities," and given in feet superficial; plaster in widths exceeding 6 in. but not exceeding 12 in. is described separately as being "in narrow widths," and given in feet superficial; plastering in widths not exceeding 6 in. must be given in feet run and the width stated. No deductions are to be made from plastering which does not exceed 4 ft. superficial.

The measurements for ceiling plaster are taken between the walls, and those for wall plastering between ceiling and floor, except where grounds are provided behind skirtings, in which case the measurement would be from the top of such grounds, but in all cases extreme measurements should be taken, and all deductions for window and door openings, etc., made at the time such doors, etc., are measured.

Plastering to ceiling beams is separated from ordinary ceiling plaster, and is described as "plastering to sides and soffits of beams," and is given in yards superficial except when in widths not exceeding 12 in., in which case it is again separated and given in feet superficial, as being in narrow widths.

All such items as labour to arrises, rounded angles, quirks, coves, cornices, etc., are measured in feet run, and all mitres, stops, etc., must be enumerated, except to arrises and rounded angles which do not exceed 1 in. in radius. No extra is measured for forming plain internal angles.

Screeds and floated beds under asphalte flats and other pavings and for wall tiling are given in yards superficial. External plastering is measured similarly to internal plastering, but should be separated and described under a heading, as such.

Wall Tiling, etc.

Wall tiling, terrazzo, and similar work are given in yards superficial, with the same rules regarding narrow widths, small quantities, etc., as have been generally described for plastering.

PLUMBER

The bill for plumbing is divided into two main sections, one being "External Plumbing" and the other "Internal Plumbing." In addition, these must be subdivided into groups of similar metals, such as lead, cast iron, wrought iron, etc.

External Plumbing

Leadwork is generally grouped as being to (*a*) flats, (*b*) gutters, hips, valleys, flashings, etc., (*c*) stepped flashings, (*d*) soakers, etc.; and the total weights are given and described as "milled (or cast) lead and labour." This means that all ordinary labours in laying, such as dressing lead flats to rolls, or dressing lead gutters to drips, etc., are not measured

separately, but must be allowed for in the prices. Labours, such as lead wedging, flashings, burning in edges of lead or bedding in white lead, dressing lead to glass or to Roman or pan tiles, dressing lead over mouldings, must be measured in feet run, and it should always be stated how much the lead weighs per foot superficial. Although lead is measured net as fixed, all extra lead in laps, welts, etc., must be added in, and where no special amounts of lap, etc., are asked for, the standard allowances are made. Bossed ends to rolls, angles and intersections to rolls, bossed angles or ends to lead dressings over mouldings or into hollows, lead rain-water chutes, lead collars and joints around pipes passing through roofs, etc., soldered dots and plugs, etc., and similar items must be enumerated.

Lead rain-water pipes, lead eaves gutters, etc., must be measured in feet run, stating sizes and weight of lead (i.e. substance), and in each case the manner of jointing and fixing must be described. In addition, all such items in connection, such as bends, branch joints, or anything else not contained in and covered by the general description, must be enumerated.

Cast-iron, steel, and other rain-water pipes and gutters are measured in feet run, and the size and weight, manner of fixing and jointing, and whether the goods are galvanised or "coated," must be clearly stated. The length measured over all bends, junctions, etc., is that taken, and all such items as bends, angles, junctions, shoes, stopped ends, outlets, etc., must be enumerated and described as being "extra over the pipe (or gutter)." Wherever special brackets or fixings are required, and it is impossible to include these with the general description of the pipes, etc., so as to give the builder a proper idea of the number required, these should be enumerated and described separately.

Cast-iron soil, ventilating, waste, and similar pipes are all measured in the same manner as rain-water pipes, but in all cases different types, weights, methods of fixing and jointing, etc., must be adequately described, separated, and grouped, as necessary. The method of jointing pipes to drains, together with the number and sizes of such joints, must be given.

Internal Plumbing and Sanitary Fittings

It is usual for the architect to state prices which are to be paid for, and the types of, sanitary fittings which will have to be installed. In cases where no prices are given, it is essential that the descriptions of sanitary fittings should be such as will leave no doubt of the type and quality required. In all cases the number of the various fittings required must be given, together with a complete description of the manner in which they are to be fixed and the work entailed (i.e. building in, brackets, etc.).

Piping

Owing to the variety of rules which govern the measurement of the pipes, etc., of different materials used in hot- and cold-water services, waste pipes, etc., detailed descriptions cannot be given here, but the *Standard Method of Measurement* gives full details of what has to be taken.

Generally speaking, lead and iron plumbing pipes are given in feet run for the net lengths as fixed, including all joints in the running lengths, and all clips, brackets, etc., for fixing purposes, all being adequately described and classified to give a clear idea of what is required. Reducing-joints, branch joints, joints connecting pipes to fittings and between pipes of different materials, bends, traps, and other fittings, etc., all have to be enumerated.

It is a good plan when measuring plumbing to commence by taking first the sanitary fittings separately as they occur, describing the fitting itself and all work in fixing; and then taking the waste pipe and trap which connect it to the main stack or waste pipe. Having completed this first operation, a good idea will have been formed of the main-stack wastes that will be required, and these can be taken next in their entirety, including their connections to the drains, etc. It may be as well to point out here that the drawings and information given to the surveyor for purposes of taking off quantities are very often of a bare character, and he has to take everything that is necessary from his own knowledge of what will be required. Having completed the measurement of fittings and main and branch waste pipes, it can then be seen what anti-siphonage or ventilating pipes will be required; and these can be taken with all connections, etc.

Cold-water Supply

The next group to measure is the cold-water supply, and this should be done by first taking an item for a connection to the water main in the road, with all stop-cocks and pits, etc., and then taking the rising main right up to the storage tank in the roof (or where required). The storage tank should then be taken, complete with ball valve, overflow pipe, and any bearers, tank encasings, or covers, etc. Branch pipes for drinking-water services or for other purposes, which are taken direct from the rising main, together with all fittings, should be measured next. Finally, measure all service pipes which run from the storage tank to the various fittings, such as lavatory basins, w.c.s, etc.

The cold-water supply from the storage tank to the heating or hot-water boilers or tanks is sometimes separated from the general cold-water plumbing, and follows the "Heating," etc., under a distinct heading in the bill, but in any case this should be kept quite separate in the dimensions.

Heating and Hot-water Supply

Heating and hot-water supply, with all work in connection, are kept under separate headings in the bill, and their method of measurement follows similar rules as general plumbing, but a very brief description of the nature of the systems should precede the actual quantities in the bill.

In conclusion, when measuring plumbing, hot water, heating, etc., all fittings, stop-cocks, etc., holes through walls, making good, and all work in connection with or caused by these services, should be taken off as they occur.

Testing

Separate clauses for the sanitary plumbing, hot-water, and heating systems should be contained in the bill, to enable the contractor to cover the cost of testing them, and any special requirements in connection should be noted.

GLAZIER

All types of glass must be separated, and the manner of fixing described. Glass fixed in woodwork must be distinguished from that fixed in metal, and wherever fixing-beads or wash-leather bedding are required, both these last items must be given separately in feet run.

Glass generally is measured in feet superficial, and must be grouped in the bill as being in panes not exceeding 1 ft. superficial ; sizes exceeding 1 ft. are then quoted in stages of 2 ft. For example, a piece of glass 3 ft. 6 in. by 2 ft. would be equal to 7 ft. superficial, and would be " 7 ft. super glass and glazing (as described) in panes not exceeding 8 ft. super." Each pane of glass must be measured individually, all fractions of an inch must be taken to the next inch, and irregular-shaped panes of glass are taken as the smallest rectangle from which they could be cut. Glass in irregular shapes must be separately described in the bill, but only " circular cutting and waste " is taken, and this is measured in feet run.

Leaded, copper, or fire-resisting glazing is very often quoted in the bill as being worth so much money per foot superficial (prime cost), but if a price is not given, then full descriptions must be given of the glass and lead, and in all cases it is measured in feet superficial without any distinctions between the sizes of panes, except as follows : (*a*) where in panels exceeding 12 in. long but not exceeding 12 in. wide, it is taken in feet run ; (*b*) where panels do not exceed 12 in. by 12 in. in size, the number required should be given.

Glazing should always be taken off at the time it occurs in doors, windows, etc.

Patent roof glazing is given in feet superficial, and if a price is not quoted it should be described in detail. Raking and circular cutting and waste must be given in feet run. It is usual when measuring roof

glazing to make all deductions of roofing, boarding, finishings to the soffit, etc., and to take all finishings around the openings, lead flashings, trimmers, etc., at the same time. Lantern lights are usually enumerated and described, a price to be paid for them can be quoted.

PAINTER

Paint, distemper, etc., should always be measured as it occurs, and must be separated as being on wood, iron, plaster, etc. The materials to be used, the preparation to be done, and the number of coats required should all be described fully, and all paintwork of a special character, painting to old buildings, or any painting which requires scaffolding, etc., to be specially erected in order to be executed, must be separately described.

Painting and distempering on general flat or plain surfaces is given in yards superficial. Skirtings, picture rails, gutters, and similar items in length, are given in yards run. All small items, such as painting back-boards to cisterns, iron air-bricks, brackets, etc., should be enumerated.

PAPERHANGER

The number of pieces of paper to be used, the prime cost per piece to be paid, and the manner of hanging, must all be quoted. The net measurement of paper required should first be obtained, and to this must be added an allowance of one piece in every seven to cover waste, but when lining paper is used, the allowance to be made is one piece in every eight. All portions of pieces should be taken as a whole piece.

Any additional paper, in borders and the like, is given in feet run, whilst special features should be enumerated.

Any work in preparing walls, or stripping and cleaning old walls, etc., must be given separately from the paper in yards superficial.

WORKING UP THE DIMENSIONS

The next step after the quantities have been taken off the drawings is to work out (or square up, as it is termed) the figures on the dimension paper into cubic feet or square feet, as the case may be. It should be noted that it is the practice to quote square or superficial dimensions as "10 yd. super," or for cubic dimensions "10 yd. cube."

The Abstract

As will have been seen from the examples of taking off, items of many different trades appear on the same dimension sheet, also similar items and additions to or deductions from various measurements occur throughout. Therefore all the items contained in the dimensions must be sorted out and collected together under the proper trade headings to

which they belong. This is done on paper ruled in columns and called "the abstract." As each item is transferred to the abstract, it should be neatly scored through on the dimension paper, and the sheet or page number from which it is taken should follow the item in brackets, so that it can be picked out easily.

As has been previously stated, all items must be abstracted under their trade headings and subdivided again into groups of similar materials or character. For example, the groups in the "founder and smith" bill would be cast iron, wrought iron, steel, etc. Again, under the trade-group headings the items are collected together as cubes, supers, or numbered items, the cheapest or smallest items coming first, and the other items following in order of cost or size. The abstract completed, its figures must be worked out and all additions and deductions made, and the total reduced to yards, etc., as required.

Preparing Bills from Abstract

Finally, the bills are prepared from the abstract, and the order is the same as on the abstract, but although the descriptions on the abstract may be abbreviated where possible, the bill must be a complete document with full descriptions which leave nothing to the imagination.

In order to reduce possibility of error, each stage of the working up should be checked by another assistant using an ink of different colour.

The working up should be done with the same care and neatness as the taking off, because the abstracts often have to be referred to when variations arise. Furthermore, careful working up often brings to light errors which have occurred in the taking off. For example, in the case of there being twenty doors of an exactly similar nature, the surveyor would take off quantities for one door completely, and then times or multiply all the dimensions by twenty : but it so happens that on occasions, although he may indicate on his dimensions by means of a side note that there are twenty doors, he omits the little formality of multiplying, and an assistant or "worker up" of intelligence will discover the error, which can then be remedied.

CERTIFICATES OF PAYMENT

It has been previously explained that building contracts are usually paid for as they proceed according to the value of the work executed, and an example of a certificate of payment has been given. It will now be shown how the work can be valued, so that a suitable figure for payment is obtained, and the first certificate for a contract will be considered.

Valuing the Work Done

It is obvious that a detailed measurement of all work completed cannot be made every time the builder requires a payment, therefore the methods adopted give only an approximate value ; but, needless to

say, an experienced surveyor, having prepared his figures, can see that the amount certified is a fair proportion of the total amount of the contract in ratio to the actual work.

The job having reached a stage which, according to the terms, entitles the builder to a payment, the quantity surveyor and the builder's representative meet on the site to value the work from the priced bill of quantities. There, by seeing what items or proportion of items contained in the bill have been completed, a figure can be arrived at. The preliminaries must be the first thing to be considered, and possibly these contain such items as clearing rubbish from the site, erecting hoardings and gantries, providing an office for the clerk of works, and similar items. All these works having been executed, and having an actual sum of money allowed for each in the quantities, it is an easy matter to make a total of them. It should be remembered, however, that such items as hoardings are usually described as "Provide hoardings, etc., and clear away when no longer required." Therefore a sum must be deducted from the amount included in the quantities for this particular item to cover the cost of taking down and removing the hoardings. The amount, so deducted, would, of course, be paid when the work was completed.

It will be presumed that the basement and all foundations have been excavated and concreted, and all brickwork and damp-proof work completed up to the ground level. Providing there have been no variations to the original scheme, it becomes a simple matter to extract the quantities and prices from the bill for the total amounts included for excavation and concrete. The brickwork will probably appear in the bill in one figure for the entire building, and it will be necessary to make a few calculations to find the value of the work finished. If the brickwork was originally taken off from the top of the concrete foundations up to ground-floor level or to a similar definite level, the run round or length of the walls can be obtained from the dimensions, and the height to which the walls have been built can be measured on the site, and the total amount of brickwork thus found. Should there be extra depths of digging and concrete than were allowed for in the bill, the lengths of the trenches, etc., can be taken from the "dimensions," and the new depths measured, and the amounts as actually completed easily found.

Value of Materials on Site

Having valued the work completed, the next thing to consider is value of materials on site. There are likely to be many bricks, much cement, sand, and other materials, upon the site at this period of the contract; and all these amounts and prices can be checked from the delivery notes of the different firms supplying. If the building be of steel-framed construction, there will probably be a lot of steelwork lying ready to be erected, and the weight of steel supplied to date can

also be obtained from the delivery notes. If there has been considerable variation to the original plans, a re-measurement of the work will probably be necessary, and it is usual for this to be done as the work proceeds ; the figures for the valuation can be obtained from the re-measurement dimensions.

All things having been considered, a sufficiently accurate total of the value of the contract to date can then be found, the amount of retention money deducted, and a certificate of payment (similar to the example given earlier) handed to the architect for authorisation.

VARIATIONS AND FINAL ACCOUNTS

The architect should keep the quantity surveyor fully informed of any variations he may make to the contract. The surveyor should keep in constant touch with the job, and take careful notes ; and when work, such as foundations, etc., is likely to be covered up or become inaccessible, he should take all measurements, necessary to enable him to make an adjustment, while it is possible.

Illegitimate Extras

Apart from legitimate extras which have been authorised, it is surprising to see what extraordinary claims for extras will be put forward by a certain type of builder, who makes a practice of purposely misconstruing descriptions in the bill of quantities, pricing the items at a low figure, and afterwards claiming extra, on the plea that the particular description did not cover the work involved. Such claims, however, cannot proceed far if the quantities have been properly prepared, and do not contain descriptions of an ambiguous or inadequate nature.

Another failing, quite common among builders, is to put forward legitimate claims for the extra cost of materials of a more expensive nature than was originally intended, and to forget to allow an omission or reduction for the whole or parts of the items included in the quantities to cover the particular work in question. By inspecting the original dimensions the surveyor can soon extract the items which have been superseded, and their full value allowed for as an " omission " by the contractor.

Bills of quantities often contain lump sums of money which are to be paid by the general contractor to any firm selected by the architect for work of a special character, such as electric-light installation. Again, the quantities often quote prices which are to be paid for certain fittings, such as items of ironmongery, sanitary fittings, etc. For all these, and similar items, the contractor must produce receipted accounts for the surveyor's inspection, to prove that the goods provided in the building are of the price and nature specified. Any differences must be adjusted.

At Completion of Contract

At the completion of the contract, the quantity surveyor and the builder's surveyor having agreed and measured all extra work, and extracted any amounts to be omitted from the original quantities where applicable, the final account is drawn up. Each item of variation should appear separately, so that where an increase of the original contract amount has arisen, the cause can be seen at once.

The amounts of all additions and omissions should be separated and collected together in a summary, which will then give the total amount of each. Finally, where the amount of additions exceeds that of omissions, the difference between them will show the net amount of extra over the contract figure. A statement can then be drawn up showing the original contract amount with the extra added ; and from this is deducted the total amount which the contractor has been paid on account, the balance being the figure owing to him.

QUESTIONS AND ANSWERS

On whose behalf does the Quantity Surveyor act ?

On behalf of the party for whom the building is being erected, generally known as the building owner.

What are Bills of Quantities used for ?

By means of bills of quantities, the quantity surveyor procures from a number of contractors definite estimates of the cost of the building and the length of time required to complete the erection.

What is the usual Procedure of Payment to the Contractor for his Work ?

Buildings are paid for during the progress of the contract according to the value of the work completed from time to time, less a percentage which is retained from each payment. In the event of the contract being satisfactorily fulfilled and without variation, the full amount of the retention money is then paid.

How is agreement, as to the Value of the Work Completed at any particular date, arrived at ?

The quantity surveyor meets the contractor or his representative, and agrees on the value of the work executed to date and the amount of materials on the site.

SURFACE TREATMENT OF CONCRETE

THE introduction of various methods of surface treatment of concrete has, by removing the drab, grey mortar face, eliminated the characterless appearance hitherto considered unavoidable.

To Avoid Cracking

Concrete being essentially an artificial stone, it is necessary so to dispose the reinforcement and to amplify it that the cracking due to the set contraction shall be narrow, and widely distributed, even if it cannot be wholly avoided, instead of concentrated at a few points in the form of large fissures. The rods for this purpose may be as thin as $\frac{3}{16}$ in.

The Vertical Joints

Having allowed for cracking, it is equally necessary to allow for joints formed at the conclusion of each day's work. In the past it was the practice to fill shuttering " all-of-a-heap," allowing the mass to flow sideways, with the result that joint lines were perfect reproductions of the angle of repose of wet concrete. The better method is to realise that joints will show however carefully they are hacked and patched, and by the use of well-fitted vertical stop-boards to give them a true vertical line conforming to the design of the building. An additional advantage is that there is yet another face of timber against which the concrete can be tamped, so that the over-all consistency of the mass is more uniform.

Shuttering

Shuttering, however carefully fitted, whether the boards be plain-edged or tongued and grooved, will persist in showing fins and replicas of wood grain. Once used it takes a great deal of cleaning if it is to go together again. The writer is of the opinion that the most satisfactory and economical shuttering is made from fabricated sheets of reconstructed wood. The load-bearing capacity is good, even with widely spaced supports ; it can be oiled with the assurance that the concrete will not stick to it, and it can be used as often as thirty times. It remains only to exercise care in constructing the forms so as to avoid wasteful cutting. Some authorities recommend galvanised-steel sheets, but if cheap they are thin, and if thin liable to rust-spots ; whilst three-ply, unless quite waterproof, is more troublesome than it is worth, owing to swelling and parting of the plies.

Removing Mortar to Disclose Aggregate

Having ensured true faces to the work, the next consideration is the treatment of the surface. Beautiful effects are obtained by disclosing the aggregate.

The removal of the mortar which hides the aggregate can be done by brush scrubbing with water, by acid treatment, or by bush hammering.

When walls are thin, the blunting of the bush hammer tool leads to a great deal of heavy vibration, whilst at the same time the fracturing of the surface of some of the aggregate, the risk of damage, and consequent neglect of equal hammering in the region of arrises, coupled with an objectionable starring effect on deep pockets of mortar, make either water or acid scrubbing preferable.

Water Scrubbing

Water scrubbing is best done with wire brushes, the ordinary dandy brush wearing too quickly. As the concrete gets harder in the course of a day's work, so the wire bristles get shorter and stiffer in compensation.

Unless the job is very large, there is usually no difficulty in arranging to strip the shuttering whilst the concrete is green, and uniform removal of the mortar is easily obtained.

The secret of success is the use of plenty of water from a nozzled hose, as it enables the workman to see quickly the results he is obtaining, whereas lack of water allows the formation of a scum or mud, and too much is removed in some places and not enough in others.

When keying concrete for plastering or rendering, use is sometimes made of delaying compounds which, being painted on the shuttering, retard the setting of the concrete in immediate contact, and this method can be used for softening the mortar for wire-brushing. The only difficulty that the writer has found is that the compound is apt to get scraped off the shuttering in patches, leaving hard places when it is removed.

Wire-brushing on green concrete was found to cost as little as 5*d*. a square yard ; the use of acid cost 10*d*. Costs vary largely, of course, in accordance with the age of the concrete.

Acid Treatment to Remove Mortar

Where the shuttering cannot be removed quickly it is necessary to use acid, a useful strength being 1 part by volume of commercial hydrochloric acid to 6 parts of water. The men should be provided with rubber boots and gloves and, in awkward places, with goggles. The acid should not be allowed to remain on any longer than is necessary, for the brushes to do their work, a hose being played on the concrete to remove every trace. As an extra precaution an alkaline solution can be applied to neutralise the acid, but it should not be required if tests are made before starting the bulk of the work so as to anticipate the amount of acid needed for the required penetration.

Other Surfacing Methods

Other methods of surfacing include the working of the face with toothed tools operated pneumatically or by hand, the former giving greater uniformity ; the grooving of the surface by electrically operated abrasive discs used edgewise, and the formation of ribs, fins, or flutes by suitably moulded linings to the shuttering.

Yet another method consists in the flat grinding of the surface to produce a terrazzo-like effect, this being particularly good when applied to floors, as by the removal of the soft cementing material the flattening of the aggregate surface exposes more of the latter to wear.

HARDENING OF CONCRETE SURFACES

A cursory inspection of the average concrete floor shows that it is neither hard nor free from dusting or disintegration, and as the surface is usually formed by a layer of some such substance as crushed granite, it is evident that the fault lies in the cement compound which binds the granite particles together.

Why Floor Surfaces Come Loose

The procedure adopted in floor construction is roughly as follows. The base concrete is dumped and fairly well rammed, and being easily got at is also reasonably dry. As the workmen approach the topmost layers, however, they commence to make the concrete more and more liquid for the purpose of being able to float it off to a good surface. This increased water–cement ratio is the beginning of trouble, for, as the men trowel or work the surface, the water rises, and they finish off with a perfect coat of laitance which has no enduring qualities and little self-adhesion. As soon as possible a rendering is run on to the base and, being unable to bond with the laitance, frequently comes loose, so that after a while the upper part is nothing but a loose skin which gives to a load, cracks, and disintegrates.

If the water–cement ratio is kept low, the whole of the laitance hacked off, and the hacked base properly brushed off so that no dust is left on it, the top rendering does not come loose.

Renderings should if possible be laid at the same time as the base. The dusting of too wet concrete with dry cement should be absolutely prohibited. It will never form a good surface.

Another fault is over-trowelling ; the semi-hardened, interlaced crystal formation breaks and causes cracks.

Use of Hardeners

Calcium chloride is often recommended as a hardener, the suggested proportion being 1 lb. of chloride to each 1 cwt. of cement. Its actual action is as an accelerator, but it is better to use rapid-hardening cement for this purpose, as the chloride, unless used with great discretion, will weaken the concrete.

BUILDING TIMBERS

NOTES ON SELECTION, MARKETING, SEASONING, PRESERVATION, AND USE

A KNOWLEDGE of wood is essential for all engaged in design and construction. There are about three thousand different timbers used throughout the world, but most of them are not marketed in this country, due to economic and political reasons. The number of woods used in the building trades, however, is continually increasing, and it is necessary to understand the peculiarities of timber to work and use them satisfactorily.

Growth

The trees that provide all our timber for use in buildings are known as *exogenous*, or outward growers. In tropical countries, *indigenous* trees, or inward growers, which include palms and bamboos, are used for all purposes, but in this country such wood is used only for small decorative articles, door furniture, inlays, etc.

Exogens

These are divided into two big groups : conifers, or softwoods, and deciduous trees, or hardwoods. This broad classification gives rise to many anomalies, as a few softwoods are hard, such as yew, and many hardwoods are very soft, such as balsa. It is the best division that can be made, however, and, usually, softwoods are lighter and softer than hardwoods. *Conifers* are distinguished by their narrow leaves, or *spines*. They are cone-bearing and evergreen, and the structure of the wood is less complex than that of hardwoods. *Deciduous*, or broad-leaved, trees, shed their leaves annually in temperate climates. In the tropics, however, many of them are evergreen.

Annual Rings

The growth of exogenous trees takes place in the cambium layer, just under the bark (see Fig. 1). Each year a new ring of wood is added to the tree, in temperate zones. These rings are called *growth*, or *annual*, rings. In tropical countries the growth is often continuous, and the number of rings is not a guide to the age of the tree.

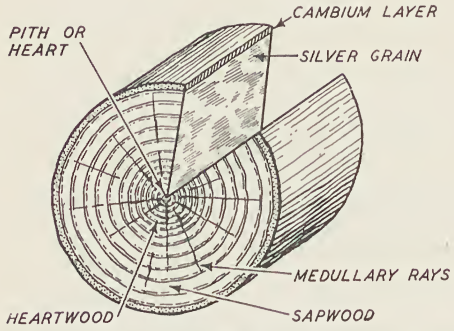


Fig. 1.—TRANSVERSE SECTION THROUGH TREE

Springwood

During the winter the sap is at rest and growth is suspended. In the spring the sap ascends and forms a layer of wood tissue called springwood ; this consists of cells with large cavities and thin walls.

Summerwood

The sun perfects the sap during the summer, and the ring is completed by the time the sap descends in the autumn. The later growth is called summerwood, and is harder, more compact, and usually darker than the springwood. Also, the cell walls are thicker and the cavities smaller.

Heartwood

During the years the inner part of the tree becomes more compact due to the thickening of the cell walls, infiltration of gums, resins, etc., and to the compression. The extent of the heartwood, or *duramen*, varies with the age and the kind of tree. In some species it is very pronounced and in others it is difficult to distinguish. Usually it is darker and denser than the outer part of the trunk.

Sapwood

The more recent growth of the tree is called sapwood, or *alburnum*. It is not so strong or durable, and is more subject to disease and decay in woodwork. Scientific seasoning, however, can improve the properties of the sapwood to resist disease, and treatment can make it as durable as the heartwood. See PRESERVATION. The sapwood of softwoods is very often a bluish colour, due to fungoid attack after felling, but it is usually greyish white in hardwoods.

Structure

The structure of wood is cellular. The size of the cells varies with different woods, and the weight varies with the size of cavity and thickness of cell walls. Softwoods consist of cells in varied formation known as tracheids, tracheid rays, and parenchyma. Tracheids are narrow, vertically elongated cells, and form the major portion of the wood, and tracheid rays are cells arranged horizontally. Parenchyma is cellular tissue whose function is to store and distribute food materials. It is arranged radially in the structure and as resin ducts. The cells are connected with slits called *pits*. Hardwoods are built up of vessels, or pores, fibres, parenchyma, and cells. The vessels are open cells forming a

continuous tube, and the fibres are long, tapering, narrow cells with closed ends. The parenchyma and wood cells are intermingled with the fibres.

Medullary rays are ribbons of tissue arranged radially, and at right angles to the axis of the tree. They consist chiefly of parenchyma cells, and in some woods can be seen only through the microscope. They are described simply as rays.

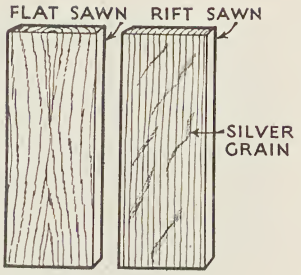


Fig. 2.—EFFECT OF CONVERSION

Classification

It is impossible to judge the characteristics of wood by its trade name, and some botanical information is essential. Trees are divided into families, subdivided into genera, and again into species. For instance, beech belongs to the family *Fagaceæ*, the genus *Fagus*, and the species *sylvatica*. It is usual to omit the family when classifying timber, but the name of the botanist responsible for the classification, in this case Linnæus, is often given abbreviated. Hence it is generally given as BEECH, *Fagus sylvatica, L.*

SELECTION AND QUALITIES

The factors governing the selection of wood are cost, fitness for its purpose, and supplies. The cost includes labour in working, which is often the greatest charge. For instance, one wood may cost five times as much as another for labour of machining and finishing. There is great variation even in the same species, as the quality of wood depends upon its position in the log, and conditions of growth : climate, soil, and surroundings.

Tests

The various tests applied to wood for different requirements include the following : specific gravity, moisture content, durability, strength (tension, compression, shear, bending), elasticity, hardness, resilience, abrasion, impact, fissibility, stability, workability, and figure. The relative values for all the above are known for those woods that have been investigated, and any information may be obtained from the Forest Products Research Station, Princes Risborough, Bucks.

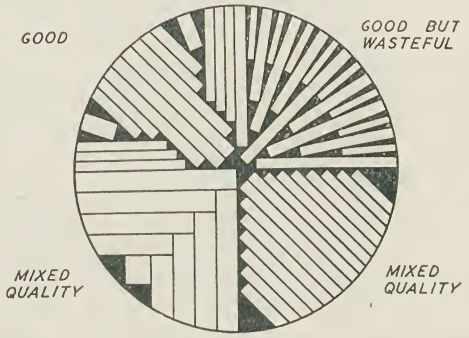


Fig. 3.—QUARTERED LOG RIFT-SAWN FOR RAY FIGURE

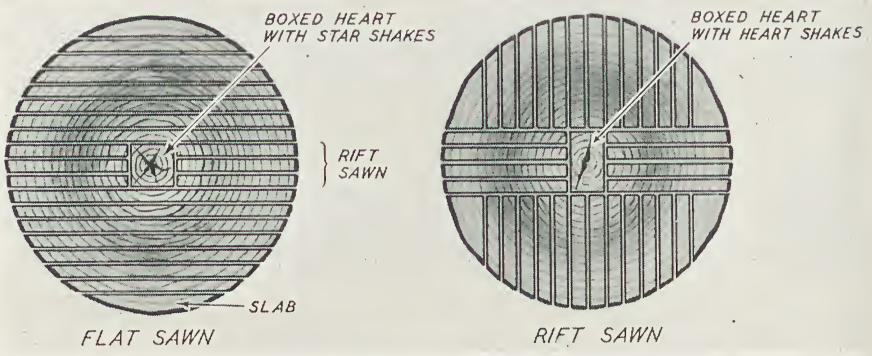


Fig. 4.—BOXED HEART CONVERSION

Strength

The strength of wood, in the same species, depends upon density (or the number of growth rings per radial inch), freedom from defects, straightness of grain, conversion, and moisture content. The actual strength can be found only by experiment, as there is great variation in different timbers. Approximate values, obtained by experience, are adopted in structural design.

Durability

The resistance of wood to varying wet and dry conditions, and to disease, depends upon seasoning, density, and an inherent quality that has not yet been satisfactorily investigated, but is probably due to the infiltration of mineral and chemical constituents. The user of wood can depend only upon experience and scientific investigation. See PRESERVATION and DISEASES.

Stability

Variation with climatic changes probably depends upon density, and cell and fibre formation. Some woods vary very little with change of moisture content, others shrink and warp considerably. Scientific seasoning usually overcomes many of the defects of refractory woods. All timbers increase in volume with increase of moisture content. See SEASONING.

Working Qualities

In softwoods, these depend upon straightness of grain, density, and freedom from knots and resin. In hardwoods, they chiefly depend upon the arrangement of the fibres and mineral infiltration. For instance, the difficulty of working mahogany depends upon fibre arrangement, and of teak upon the hardening of a secretion. The natural hardness and straightness of grain are also important factors. See GRAIN AND FIGURE.

FELLING AND CONVERSION

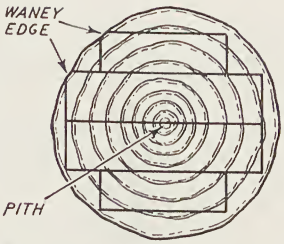


Fig. 5.—CONVERTING REDWOOD DEALS

Felling

Trees should be cut down when the sap is at rest and when the tree is at maturity. In northern countries they are felled in the winter months and moved after the frosts, so that the rivers can float the logs to the mills. In tropical countries it is common to girdle trees about two years before felling. If the tree is felled before maturity there is a greater proportion of sapwood. Trees are felled either by axe or by saw, very often by machine saw. Softwood trees are usually cut near to ground level, but buttressed hardwoods are often cut from platforms as high as 20 ft. above ground level.

Conversion

The breaking down, or conversion, of a log into market sizes is of great importance, and the value of the wood depends upon correct methods being used for different requirements.

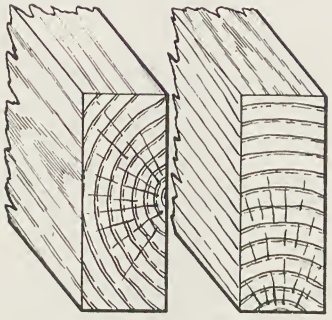


Fig. 6.—CONVERTING JOISTS

Flat- or Bastard-sawn

This term is applied to wood cut tangential to the growth rings. The irregularity of the rings produces handsome grain, called flat or slash grain, on the face of the stuff in such woods as walnut, pitch-pine, etc., where there is a contrast between spring- and summerwood.

Rift- or Quarter-sawn

This is applied to wood cut radially; that is, towards the centre of the log. It is called edge, vertical, or straight grain. There is great variation in this method of converting, to avoid waste. Hence, in most conversion, the result is a combination of flat- and rift-sawn wood. Quarter-sawing produces silver grain, ribbon grain, ripple, etc., and the stuff is less liable to shrink and warp than flat-sawn wood. It is the best method for floorboards, as there is no *heart* to lift, and the abrasive qualities are increased.

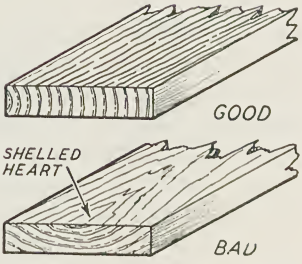


Fig. 7.—CONVERTING FLOORBOARDS

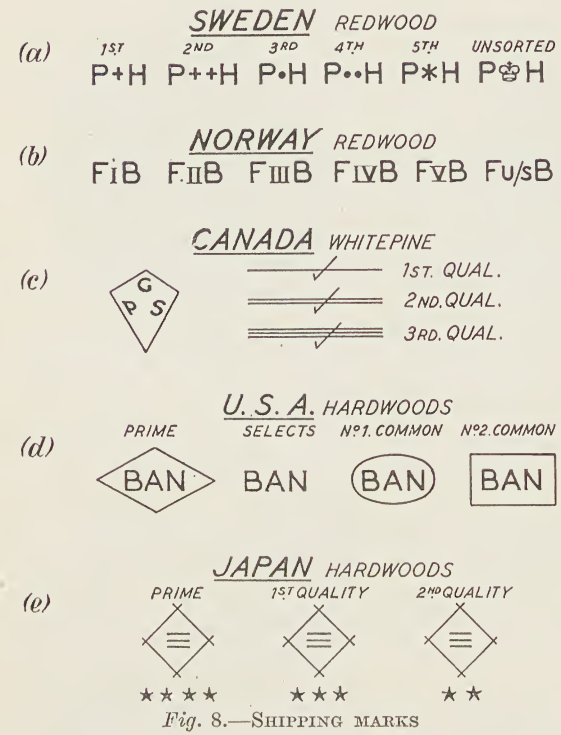


Fig. 8.—SHIPPING MARKS

Boxed Heart

The boxing of the heart is adopted for many hardwoods. A piece about 4 in. square, including pith and heart shakes, is scrapped.

For other methods of conversion see VENEERS.

Market Forms

The following names are given to the market sizes of converted wood : log, balk, plank, deal, planchette, batten, board, quartering, planking, scantling, die square, flitch, mast, pole, casewood, pitwood, firewood. The last three are of little importance to the builder, except in special circumstances. In many cases the dimensions vary a little at different ports.

Log.—A felled tree, with branches lopped off, and sawn to the required length.

Balk.—A squared log.

Flitch.—A rectangular part of a log not less than 4 in. by 12 in., and suitable for further conversion. A part of a log trimmed and prepared for conversion into veneers.

Die Square.—Large-dimensioned stuff of square section. It is between quartering and balk in size, and free from wane.

Plank.—Applied to converted softwoods above 2 in. by 10 in., and to hardwoods above $1\frac{1}{2}$ in. by 9 in.

Deals.—Converted European softwood, white and red, between 2 in. and 4 in. thick and 9 in. and 11 in. wide. A deal in U.S.A. softwoods is between 2 in. and 5 in. thick and over 6 in. wide.

Quarterings.—Squared stuff of small section, from 3 in. by 3 in. to 4 in. by $4\frac{1}{2}$ in. Small stuff approximately square in section.

Boards.—Softwoods under 2 in. thick and over 5 in. wide, and hardwoods of any width and up to $1\frac{1}{4}$ in. thick. Boards are also marketed as floor-, match-, and weather-boards, sawn or prepared.

Planking.—A general term for prepared wood for the decks of ships, quays, wharves, etc., and for flooring thicker than normal flooring, scaffold boards, etc.

Planchettes.—Narrow boards under 4½ in. wide.

Scantlings.—In the European trade this term is applied to softwoods over 8 ft. long, over 2 in. thick, and under 6 in. wide. For U.S.A. softwoods, it is applied to stuff under 6 in. wide and between 2 in. and 5 in. thick.

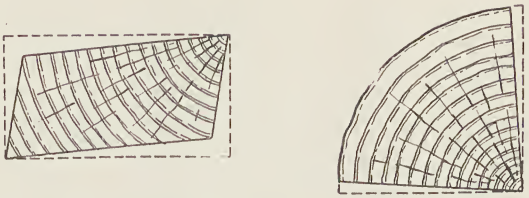


Fig. 9.—Showing effect of shrinkage

Ends.—Deals under 9 ft. long.

Battens.—Softwoods from 2 in. to 4 in. thick and from 5 in. to 8 in. wide. The term is also applied to small stuff for special purposes, such as slate battens.

Thick Stuff.—Softwoods over 8 ft. long, 5 in. thick, and 6 in. wide.

Masts.—Logs over 24 in. in circumference.

Poles.—Logs under 24 in. in circumference.

Casewood.—Small clean stuff, called off-products, in white softwood, usually fir and spruce.

Pitwood.—A variety of round and sawn wood suitable for mine timbers.

Firewood.—Ends up to 5 ft. 6 in. long. It is sold by the piled fathom measure.

MARKETING

Each timber-producing country has its own organisations and rules for the marketing of timber. The following are the important terms used in the timber industry from the user's standpoint.

Standard.—Softwoods are sold by the Petrograd standard of 165 cu. ft. This is the *standard hundred*, and consists of 120 pieces of certain dimensions, or their equivalent. There are other standards, but they are seldom used: Christiania, 103⅛ cu. ft.; Dammer, 121⅞ cu. ft.; Dublin, 270 cu. ft.; Quebec, 229 cu. ft.

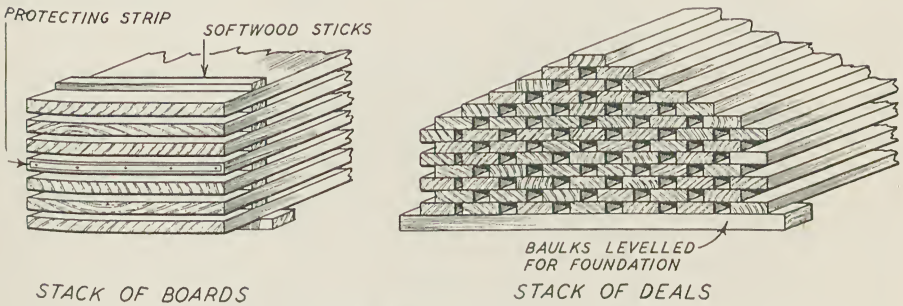


Fig. 10.—Stacks of boards and deals

Board Measure.—This is the North American unit of measure, which is stated in square feet of 1 in. thick, or its equivalent. That is, a board 12 ft. by 12 in. by 1½ in. contains 18 board ft.

Load.—A measure of 40 cu. ft. for unhewn stuff, and 50 cu. ft. for squared softwoods, or 600 sq. ft. board measure.

Float.—Consists of 18 loads.

Fathom.—A volume of 6 ft. cube or 216 cu. ft. This measure is used for ends, casewood, etc. The volume is measured by packing the stuff in a special frame 6 ft. by 6 ft. by 6 ft.

Hardwoods

These are usually sold by board measure, or by cubic measure for logs and large sections. There is a number of special rules framed by different organisations for the measuring of hardwoods, that allow for loss in conversion, defects, irregular dimensions, etc. Valuable heavy hardwoods, such as lignum vitæ, are sold by weight. (See pages 4–16.)

Shipping Marks

These are private trade-marks to denote the quality of the timber. Every combination of letters, signs, and colours is in use. Different combinations are used for different sizes and qualities, and they are painted or stamped on each piece. It is impossible to give more than a general impression of those even in common use, as it would require about twenty pages of this work to give the firms and their marks for Sweden alone. Unless one knows the firm exporting the timber, the trade-mark has no significance to the user.

The selection in Fig. 8 has been made because they have some significance as to the quality, and to show some of the variations in common use. The method adopted by a Stockholm firm for denoting six different qualities of redwood is shown at (*a*), and (*b*) shows that of a Norwegian firm for the same kind of wood ; (*c*) shows the mark of an Ontario firm for white pine, and (*d*) shows four qualities of hardwoods from a U.S.A. firm ; (*e*) is the mark of a Japanese firm exporting only three qualities, chiefly oak.

SEASONING

Seasoning is an important factor in the strength, durability, and stability of wood. Many timbers lend themselves readily to seasoning and are naturally stable, but others are very refractory ; hence, many woods require expert treatment to avoid warping and checking. Seasoning implies the reduction of the moisture content and the hardening of the natural juices of the wood. Careless seasoning causes checks and distortion, especially on reconversion, due to case-hardening. The loss of weight on seasoning is from 15 to 35 per cent., and the shrinkage is

about 1 per cent. longitudinally, 4 per cent. radially, and from 6 to 15 per cent. tangentially. (See Fig. 9.)

Moisture Content

This term is used to denote the percentage of moisture present in wood. The moisture may exist (*a*) free in the cell spaces, (*b*) in the cell walls, and (*c*) in the protoplasm. It may be in all three conditions in the sapwood, but only in the first two in the heartwood. The following are suitable percentages for seasoned wood : interior work—central heating, 10 per cent., ordinary heating, 12 to 14 per cent., exterior work, 16 per cent. When the moisture content is less than 12 per cent. it is said to be kiln-dry.

Natural Seasoning

The converted wood is arranged in stacks or steers. In the former the stuff is laid horizontally, and in the latter the boards are reared on end. The wood should be protected from sun and rain, and well ventilated. Strips of wood or hoop-iron, or paint, are put on the ends of hardwood to prevent checking. *Stickers, sticks,* or *skids* are placed between boards to allow for ventilation. These sticks must be of uniform thickness in the same layer, and of softwood, to prevent staining. This method takes several years for some hardwoods. (See Fig. 10.)

Wet Seasoning

The logs are submerged in running water for a considerable period. The running water washes out the sap, but may influence the colour and elasticity of the wood ; but it is a satisfactory method for some timbers.

Girdling

A ring of the cambium layer is removed about two years before the tree is felled, to prevent further movement of the sap. Many timbers, such as teak, are best treated in this way as a preliminary to seasoning.

Kiln Seasoning

This is the modern method, and has superseded the foregoing for most timbers. It is quick, and always under control. The moisture is brought to the surface, and drying is controlled by steam heating. Warm, humid air is kept circulating, and surplus moisture extracted from the air. This prevents case-hardening, so that the wood does not warp or check on further conversion.

There are many types of kiln. The Forest Products Research Laboratory suggests that the overhead internal fan kiln is the most economical and efficient for normal purposes. The kiln may be up to 50 ft. long, and of sufficient size to take two stacks not more than 9 ft.

high by 6 ft. wide, to ensure good circulation. A heating surface of 1 sq. ft. per 10 cu. ft. of kiln volume is suggested.

Second Seasoning

Framed woodwork is usually placed in a warm, dry room for some time before it is glued up, to bring the wood to the equivalent moisture content of the atmosphere in which it is to be fixed. This also applies to match-boarding, panels, mouldings, etc.

PRESERVATION

Many woods not naturally durable may be made very durable by treatment, and the life of durable woods can be considerably increased. The best method is by impregnation, but some woods lend themselves more readily than others to this method, and often an incising machine is used to assist the more dense and difficult woods. Oils or chemical or mineral solutions are forced into the cells of the wood to increase the resistance against insect attack, disease, and decay.

Effective solutions are salts of arsenic, copper sulphate and chromate, mercuric chloride, sodium fluoride, zinc sulphate or chloride, zinc meta-arsenite. Some of these are poisonous, such as arsenic and mercury, hence they are not in general use except in the tropics. They can be painted over, which is an advantage.

There are a number of well-known processes named after the inventors: Boucherie (sulphate of copper), Burnett (zinc chloride), Blythe (carbolic and tar acids), Kyanising (mercuric chloride), Wolman (dinitrophenol and sodium fluoride), Noden-Brettenau (electric seasoning), Powel-Wood (saccharine). Some of these, however, have been superseded by newer methods. Perhaps the best solutions in order of merit are creosote, Wolman salts (2 per cent. solution), and sodium chloride (2 per cent. solution).

Pressure Plants

Creosote.—The usual type of plant consists of a large cylinder, up to 2,000 cu. ft. capacity, a mixing or storage tank, a pressure chamber, and a steam-heating boiler. The wood is run into the cylinder on carbunks (trolleys), the air is exhausted to form a vacuum, and the creosote forced into the cylinder under a pressure of nearly 200 lb. per square inch and at a temperature of about 180° F. The air is withdrawn from the wood cells, which are then filled with creosote. In the *full-cell* method the creosote is allowed to remain free in the cellular spaces; in the *empty-cell* method the free creosote is withdrawn by suction, and only that absorbed by the wood tissue remains. The full-cell process is too expensive for ordinary purposes, and the usual method is to allow a definite amount of oil per cubic foot. It is usual to allow 10 lb. per cubic foot for redwood sleepers. This description is of general application to pressure impregnation, but different preservatives require some variation.

Open-tank Method of Applying Creosote

The wood is steeped in a tank of creosote oil until the required amount has been absorbed. This is not so effective as the pressure method, but it is cheaper for small quantities.

Applying creosote with a brush is not satisfactory, and affords only temporary protection. For conditions where the smell of creosote is objectionable, various proprietary preparations may be used from which the pungent smell has been removed to a large extent. These include "Cuprinol," "Solignum," Hope's "Destroyer," "Peterlineum," etc.

Coatings

Tar is an excellent preservative coating, either coal tar or Stockholm tar.

Paint is a favourite method because of the decorative effect. It is satisfactory if properly applied on dry timber, and periodically renewed.

Charring is very effective for the feet of fence posts, etc.

Resistance to Fire

Many timbers have a natural resistance against fire, and the following are recognised by the London County Council as fire-resisting : crabwood, English ash, jarrah, karri, meranti, mora, Nigerian walnut, oak, padauk, pynkado, Rhodesian and Secondi mahogany, silver greywood, Tasmanian myrtle, teak. This list is continually increasing as new woods are investigated.

Other woods may be made fire-resisting by chemical impregnation. Ammonium chloride or phosphate or sulphate, calcium chloride, borax, alum, are some of the solutions used. The chemicals crystallise in the pores, from which air and moisture have been extracted. In the event of fire, in some cases the heat generates non-inflammable gases that drive out the air ; in other cases the chemicals fuse and glaze the cell walls and prevent access of oxygen from the air.

There are also proprietary paints on the market, such as "Porcella," that are very effective.

DISEASES AND DEFECTS

There are many diseases to which timber is subject. It is only necessary for the user to be able to distinguish when disease, of any kind, is present, and in all cases the wood should be scrapped. In a few cases, however, fungoid attack may increase the decorative value of some hardwoods. (See FIGURE.)

Seasoned wood in a dry, ventilated position is not liable to disease, whilst impregnation with preservative is a guarantee against future attack. Decayed wood can be distinguished by the odour. Most woods have their characteristic odour, and the sawyer can tell if there is any

variation due to disease or decay. The most important diseases are decay, dry rot, wet rot, doatiness, druxiness, foxiness, plethora. Insect attack is not a disease, but is equally destructive.

Decay

This is disintegration or decomposition of the wood tissue, due to over-maturity and the action of organisms such as bacteria and fungi. There is great variation in the natural resistance of different woods to different organisms (see DURABILITY). Decay is usually accompanied by discoloration, brittleness, decrease in density, and an unusual odour. It usually begins at the heart of growing trees, but in the sapwood in converted timber.

Doatiness

Dote, dosiness, foxy, deat, and druxiness are all terms used by lumbermen for localised, or incipient, decay. It is distinguished by discoloration, speckles, stains, and unpleasant odour, and is caused by fungoid attack on wounds in the growing tree.

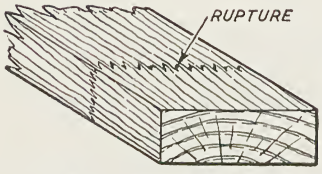


Fig. 11.—UPSETT

Dry Rot

This is a general term for the most destructive wood diseases known in this country. It is due to fungi attack. There are several varieties, but they can be distinguished only by experts. The most common is *Merulius lacrymans*. The timber is covered with a yellowish or greyish blanket-like substance, with darker patches and an unpleasant odour. The disease is contagious, and spreads rapidly in moist, stagnant air, and reduces the wood to a cracked, friable mass.

It is difficult to eradicate when once established, as the spores get into the mortar joints of the brickwork. All infected and suspected wood must be removed and burnt at once. The remaining timbers should be coated with a strong preservative such as corrosive sublimate (1 oz. per gal. of water, applied hot), creosote, sulphate of copper, hot lime, or a proprietary preservative. The walls should be treated with a blow-lamp, and the joints raked out and repointed.

The most important thing is to remove the cause, which is dampness and lack of ventilation. It is possible for spores to be in new wood, but they will not develop unless conditions are favourable. Another precaution is to remove all vegetable matter from under ground floors.

Wet Rot

This term is used in several senses. It may imply some form of dry rot that requires a very wet situation, or certain fungoid growths that

attack growing trees. The woodworker generally applies the term to exposed wood, such as the foot of a fence post, that is decayed or decomposed.

Brown Rot.—This is due to fungoid attack in which the cellulose compounds are removed, leaving a brown, friable mass with a large amount of lignum present. *White rot* has the coloured constituents removed, leaving a white substance that is chiefly cellulose.

Defects

Nearly all defects reduce the strength, but many of them improve the appearance, and some only lessen the volume in conversion. The defects common to wood are : bark pockets, brashness, burrs, callus, cross-grain, gum veins, knots, pith, pockets (pitch or resin), pollard, rindgalls, shakes, short grain, stain, twisted grain, upsetts, wandering heart, wane, warp, worm holes.

Bark Pockets.—These are portions of bark buried in the wood. They are due to a wound in which the bark has been covered by later growth.

Brashness.—See *Short Grain.*

Burrs.—These are excrescent growths, or protuberances, found in many trees. They are due to growth round a wound or dormant buds, and in many cases they are artificially produced. The growth is irregular and contorted, and produces beautiful figure in such woods as walnut, oak, etc. Burrs are also called rindgalls.

Callus.—This is a growth of tissue over a wound, and has the appearance of an irregular, solid bubble. Like the burr, this often adds to the decorative effect.

Checks are shakes in the converted wood, in which the fibres are separated longitudinally but not through the whole of the cross-section. A *boxed-heart check* is one wholly contained in the piece, due to enclosing the heart, and does not appear on the surface. *Honeycombing* is also applied to checks not visible on the face. *Slash check* is a term applied to the raising of the fibres along the growth rings as they break out on flat-sawn wood. A *surface check* is one practically confined to the face of the stuff. Also see *Shakes.*

Cross-grain.—A term applied to wood in which the grain does not run in one direction, or lengthwise of the piece. This may be due to irregular growth rings and intersection of branch with trunk, or to the varying inclination of the fibres as they intersect the face of the material.

Gum Veins.—These are excessive accumulations of gum found in hardwoods, and a bad defect when they break on the face of the stuff.

Knots.—These are parts of branches embedded in the timber, and may prove a serious defect in structural work and framed timbers. The B.S.I. have standardised a number of descriptions for the various types : a *branched knot* is two or more knots branching from a common centre. A *dead knot* is one not joined throughout to the surrounding wood. A

decayed knot is one infected by fungus. An *enclosed knot* is one that does not show on the face of the stuff. A *loose knot* is a dead knot shrunken away from the surrounding wood. A *pin knot* is not more than $\frac{1}{4}$-in. diameter. A *sound, tight,* or *live knot* is one joined firmly throughout to the surrounding wood, and free from decay. When the branch is cut obliquely, at right angles, or longitudinally, the resulting knots are called *oval* or *oblique, round,* and *spike* or *splay* knots respectively.

Pith.—This is the heart, or medulla, and is the central core, consisting chiefly of parenchyma or soft tissue, round which the growth takes place. If it breaks on the face it crumbles away and forms a bad defect.

Pith Flecks are due to insect attack in the tree, and appear as pith-like streaks of discoloured tissue.

Pockets.—These are large localised deposits of pitch or resin. They weaken structural timbers, and are a serious defect in joinery when they appear on the face of the material.

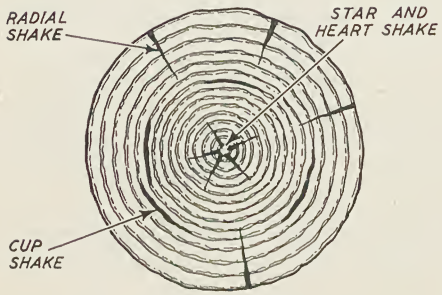


Fig. 12.—SHAKES

Pollarding.—See FIGURE.

Rindgalls.—See *Burrs.*

Sapwood.—Many specifications prohibit the use of sapwood. It usually differs in colour from the heartwood, is less durable, and more liable to attack by insects and disease. There is little objection to its use, however, for painted work if it is properly seasoned. If it is treated with preservative it is satisfactory for all purposes.

Shakes.—A split due to a cleavage or separation of the fibres. The term is now associated with logs and large-dimensioned timbers. See *Checks.* A *compound shake* is a combination of other kinds. A *cup, ring,* or *shell shake* follows the direction of the growth rings, and is due to lack of nourishment or to heavy winds or to unequal growth. A *heart shake* radiates from the centre, or heart, of the log. It is caused by shrinkage through uneven seasoning, or to over-maturity, when the rays fail to convey food to the inner part of the stem. A *star shake* consists of several heart shakes in star-like formation. *Radial shakes* start at the circumference and converge to the centre. They are due to uneven seasoning, or to severe frost bursting the tissue, or to the sun drying up the cellular tissue through a wound in the bark. Shakes cause waste in conversion but are not detrimental to the quality, except heart shakes when due to over-maturity. (Also see *Upsetts.*)

Short Grain.—This term is applied to wood that breaks with a short fracture and with little splintering. It is also called brashness.

Stain is a variation from the natural colour and may be due to fungoid

attack or chemical action. *Blue stain* is due to fungus attacking the sapwood, but it does not decompose the cellular structure, or fibres. *Sap stain* is a similar defect. There are several stains in oak, and certain other hardwoods, that increase the value for decorative work. They are known as brown-oak, golden-oak, or yellow stain, and grey stain. Stains due to chemical action only affect the appearance. They are usually confined to hardwoods, as the blue-black stain caused by iron or tannin in the wood. This is prevalent in oak. Many coloured hardwoods change colour with exposure, and the appearance may be impaired by long or careless stacking, with natural seasoning.

Twisted Grain.—This is a defect in wood from trees that have been exposed to strong winds. The wood is short- or cross-grained, which is a serious defect for structural members, mortices and tenons, etc.

Upsetts.—This defect is more correctly described as *rupture.* It is also called transverse shake, cross-fracture, and felling shake. It is a serious defect, and often difficult to detect in sawn stuff. The fibres are completely severed across the wood, so that a jar may break it into two pieces. The suggested causes are: felling across an obstruction, the banging of one log into another while floating down a river, or severe thunder-storms. The defect is prevalent in tropical hardwoods, especially mahogany.

Wandering Heart.—This is due to irregular, crooked growth in the young tree. Converted wood is liable to warp and is cross-grained.

Wane.—Waney edge describes converted timbers in which one or more corners are not square, due to too economical conversion, so that a rounded part of the surface of the tree remains. It is also accompanied by sapwood.

Warp.—Several terms are used to describe this defect, which is distortion or twist in the converted wood due to stresses set up by faulty seasoning. It is difficult to avoid, however, in naturally twisted and refractory woods. *Bowing* is curvature in the direction of the length. *Cupping* is curving across the face, so that the edges are straight but the board is hollow. *Spring* is applied to a piece that is flat but bent edgeways, that is, bent in its own plane. *Twist* is winding, or spiral distortion.

Worm Holes.—The chief danger of this defect is the probability of wood-borers or larvæ still being present. The holes detract from the appearance, but they may be *stopped* for most purposes. If the holes are $\frac{1}{16}$-in. diameter or less, they are *pin holes*; between $\frac{1}{16}$ in. and $\frac{1}{8}$ in., *shot holes*, and over $\frac{1}{8}$-in. diameter, *worm holes*. They are also called *exit* and *flight* holes.

WOOD-BORERS

There is a great variety of insects destructive to trees and timber, including ants, beetles, bugs, termites, and marine borers.

Ants

There are about ten species destructive to wood, but they are chiefly associated with the tropics. The most destructive is the white ant, *Termes fatalis*, which is a termite, not an ant. Very few woods are able to resist its ravages, without treatment. Arsenic, paraffin, creosote, and several proprietary preparations are effective against all insects. (See PRESERVATION.)

Beetles

In this country the most destructive insects are beetles. Many of them, however, attack only the growing tree. The best known are: death-watch, furniture, black carpenter, cockchafer, elephant, longhorn, powder-post, and sipalus.

Death-watch Beetle—Xestobium rufo-villosum.—This beetle is of the *Anobiideæ* family, and attacks interior constructional timbers. The insect is about $\frac{1}{4}$ in. long, dark brown colour, with a mottled appearance due to patches of yellowish hair. The grubs burrow into the wood, over a period of two years, before emerging into the chrysalis stage. The adults make a ticking noise that superstition associates with death, hence the name. They are very difficult to eradicate when firmly established, owing to the depth of the burrows. Fumigation by gas, carbon disulphide, etc., or preservatives such as "Cuprinol," etc., are effective.

Furniture Beetle.—The common furniture beetle, *Anobium punctatum*, is closely related to the death-watch, but smaller. It is very destructive to fixed joinery, furniture, etc. The cure is to fumigate, or to inject a strong insecticide into the flight holes, joints, and crevices, to destroy the eggs and larvæ.

The black carpenter beetle, *Alaus*, and the longhorn beetle, *Hylotrupes*, are also very destructive to old timber, but they are large and easily caught. The powder-post beetle, *Lyctus*, attacks stacked timber in the yard.

Marine Insects

The best-known and most destructive of this type of borer are the shipworm and the gribble. The shipworm, *Teredo navalis*, can destroy a 12-in. pile in less than six months. In some waters timber must be treated, or sheathed with muntz metal, as a protection. These molluscs resemble worms, and are found up to 4 ft. long and $\frac{1}{2}$-in. diameter. They honeycomb the wood with holes up to 1-in. diameter. The gribble, *Limnoria lignorum*, is of the *Crustacea* family. It attacks the outer surface of the wood; and the action of the water exposes fresh surfaces until the piles, etc., are eaten away.

GRAIN AND FIGURE

It is difficult not to associate the terms grain and figure. Both are used indiscriminately, in many cases, to describe the same thing. The woodworker generally uses the term *figure* when the wood is unusually decorative, and *grain* to describe figuration due to growth rings.

Grain

There is a number of standardised descriptions (see DEFECTS and CONVERSION). The term is used to denote the arrangement of the fibres or wood elements, or the figure produced by these varied arrangements on the surface of the wood. *Curly* or *wavy grain* denotes irregular curves in the arrangement of the fibres. *Diagonal* or *oblique grain* is applied to converted wood in which the fibres do not run parallel to the axis of the stuff. *End grain* is a cross-cut surface showing the ends of the growth rings. *Spiral grain* is the arrangement of the fibres in a spiral direction round the annual rings. This kind of grain is usually difficult to work smooth. *Interlocked grain* is spiral grain, but with a periodic change in direction. *Straight grain* is applied to wood in which the fibres run parallel to the surface of the material. *Wide-ringed grain* describes wood with wide growth rings, due to rapid growth. The reverse is called *narrow-ringed grain*. These are also called *coarse* and *fine* grain respectively.

(See CONVERSION for flat-sawn, quarter-sawn, edge, and slash grains ; and DEFECTS for cross-, short, and twisted grains.)

Figure

This term is used to describe any ornamental markings in wood. *Normal figure* is due to grain, rays, branches, interlacing of fibres, and the effect of light and shade, variation of colour, and pressure on the bark due to wind, etc. *Abnormal figure* is due to defects, parasites, fungi, insects, birds, wounds, stooling, pollarding, decay.

The names given to the variations are the result of the imagination perceiving some resemblance to a familiar object, as ram's horn, bird's eye, feather, etc. About twenty different terms are used for mahogany alone, although many of them are applicable to similar figure in other woods.

Feather or *Crotch* is due to the struggle for direction of the fibres between branch and stem, or between two branches springing from a common centre. It is especially valuable in mahogany.

Bird's or Peacock's Eye.—These small irregularities are due to insects and birds in search of sap, or the sinkers of parasites such as mistletoe, lianes, etc., or the depressions may be made artificially. Succeeding growth rings follow the same contour, and flat-sawn or rotary-sawn wood shows a series of small concentric circles.

Interlocked, Spiral, Lustre, Roe, Ribbon grain are all due to the direction and twist of the fibres and the way in which they intersect the surface. The beauty is largely due to reflected light and colouring. Some of these variations are closely allied to ripple.

Mottle.—This term is applied to wood that gives the impression of an uneven surface, that tempts one to feel if it is smooth. Mottle may be due to indentations in the surface of the tree, or as explained for ripple. There are several variations, as plum, stop, fiddle, ram, and peacock mottle, etc., according to the combination of effects obtained.

Silver Grain, Ray, Flake, or *Plash* are all applied to rift-sawn wood in which the outcrop of the medullary rays is prominent, as in oak.

Ripple, Fiddle-back, Ram's Horn, Roe, Wavy Grain, Lacewood, Honeysuckle are all variations, due to the same cause, in different woods. The wind probably causes the growth rings to wrinkle, or bend, in wave formation. Uneven pressure of the bark also produces wavy figure.

Burr or Burl.—The most beautiful sawn veneers are due to burrs. See DEFECTS. In many cases burr wood is from the stumps of trees that have the property of *stooling.* After felling, the stump throws out new shoots, which are broken off to form burrs. A repetition of this through the centuries has produced the beautiful North African thuya. Burr wood is specially valuable in amboyna, ash, elm, oak, walnut, yew, etc.

Pollard.—This is similar to burr, but more specially applied to oak. When the top of the tree is removed future stooling produces a large head, or mass of burr wood.

Watermark.—This term is applied to the beautiful figure in Japanese oak due to fungoid attack. It has the appearance of rippling water.

Oyster Figure is the result of a splayed cut across a branch, showing the complete cross-section in the form of concentric ellipses.

SOFTWOODS

Key to Descriptions

The botanical name is given in *italics,* and the chief source of supply in brackets. The safe working values, for structural timbers, are given for air-dry timber and for good average qualities ; and the following abbreviations are used : *S.G.*, specific gravity (multiply by 62·3 for weight in pounds per cubic foot) ; *C.W.*, comparative workability (showing the approximate cost of finishing woodwork, compared with yellow pine) ; *E.*, modulus of elasticity (m. = million, units pounds and inches) ; *C.*, safe crushing strength (in pounds per square inch, for short lengths) ; *R.*, extreme fibre stress (in pounds per square inch, bending) ; *S.*, safe horizontal shear (pounds per square inch).

The names are those suggested by the British Standards Institution. They have been selected as standard names for use in this country, to avoid the present confusion. Only those woods are described that are in general use and of which supplies are easily obtainable.

Cedars

There is a great variety of cedars, including softwoods and hardwoods (see HARDWOODS). The softwoods are light, soft, very durable, fragrant,

easy to work, and resist most insects. WESTERN RED CEDAR, *Thuja plicata* (N.W. America). Pinkish to light reddish brown, weathering to grey. Light, soft, very durable, strong but brittle. Close, straight, even grain. Stable, easily wrought, stains and polishes well, and resists insects. Large sizes and plentiful supplies are obtainable. It is used for joinery, constructional work, greenhouses, shingles, flooring, plywood, etc. *S.G.* ·4 ; *C.W.* 1·75 ; *E.* 1 m. ; *C.* 800 ; *R.* 900 ; *S.* 80.

EASTERN WHITE CEDAR, *Thuja occidentalis* (N.E. America), is not so strong as western and of smaller sizes, but it is very durable and a useful timber. YELLOW CEDAR, *Cupressus nootkatensis* (N.W. America), is a cypress, and is harder and more difficult to work than western cedar, and smaller sizes are available, but it has many similar characteristics and properties. PORT ORFORD CEDAR, *Cupressus Lawsoniana*, is also a cypress, and similar to yellow cedar. PENCIL CEDARS, *Juniperus spp.* (E. Africa and U.S.A.), are used chiefly for pencils and cabinet work.

Chil, or Chir

Pinus longifolia (N. India). The appearance and properties of this wood are between those of yellow pine and redwood. It is slightly heavier than redwood, and not so durable. Some specimens are mottled and lustrous, and used for joinery and cheap furniture.

Cypress

Cypress is a yellowish brown wood with reddish markings, that darkens with exposure. It is lustrous, fairly soft, light, strong, and very durable. It has a fine uniform grain, is easily wrought, and has many of the characteristics of cedar, and is a useful wood for interior or exterior work. The chief varieties marketed in this country are SOUTHERN CEDAR, *Taxodium distichum* (U.S.A.), and HIMALAYAN CYPRESS, *Cupressus torulosa*. See CEDARS.

Douglas Fir

Pseudotsuga taxifolia (British Columbia). This is one of the largest, strongest, and most useful softwoods. Plentiful supplies of very large sizes, free from defects, are obtainable. Balks 70 ft. by 4 ft. square, and flag poles 200 ft. long, have been used. It is pinkish to light reddish brown, with handsome grain due to contrasting spring- and summerwood. It is resinous, strong, and fairly durable ; easily wrought and seasoned, and stains and varnishes well. The prominent grain makes it often difficult to paint. It is used for all purposes in building. *S.G.* ·5. ; *C.W.* 1·75 ; *E.* 1·5 m. ; *C.* 1,000 ; *R.* 1,400 ; *S.* 100.

Firs

The true firs are confined to species of *Abies*, but there is great confusion with other species. The woods of the *Abies spp.* are similar in

texture and appearance. They are nearly white, with yellowish markings, soft, light, strong and elastic for their weight, and not very resinous. The firs have similar qualities and characteristics to spruce, but they are inferior, although they are often graded with spruce. Fir is easy to work except for the small, hard knots that are prevalent. It is the most commonly used wood for lower-class carpentry and joinery. It takes paint well, and must be treated for exterior work as it is not durable. The chief supplies are: ALPINE FIR, *Abies lasiocarpa* (Western N. America); AMABILIS FIR, *A. amabilis* (W.N. America); BALSAM FIR, *A. balsamea* (Canada); GRAND FIR, *A. grandis* (British Columbia); HIMALAYAN SILVER FIR, *A. pindrow* (N. India); NOBLE FIR, *A. nobilis* (Western U.S.A.); SILVER FIR, *A. alba* (C. Europe). See SPRUCE and WHITEWOOD. *S.G.* ·35; *C.W.* 1·25; *E.* 1·1 m.; *C.* 800; *R.* 1,100; *S.* 75.

Hemlock

There are two species, imported from N. America. WESTERN HEMLOCK, *Tsuga heterophylla* (Brit. Columbia). Pinkish colour or reddish brown tinge. Moderately light and soft, free from resin, and with distinctive grain. Fine, uniform texture, easily wrought, and fairly durable. Requires careful seasoning to prevent warping, and shrinks freely. Used for constructional work, joinery, flooring. EASTERN HEMLOCK, *Tsuga candensis* (Canada), is generally inferior and more difficult to season than western, but it is a useful wood for many purposes. *S.G.* ·43; *C.W.* 2; *E.* 1·4 m.; *C.* 1,000; *R.* 1,300; *S.* 85.

Kauri

Agathis spp. (New Zealand, Queensland, Fiji Island). Light yellowish brown and lustrous. Fine, even grain and texture, and very strong and elastic. Easily wrought, stains and polishes well, and used as a substitute for many hardwoods. Large sizes free from defects. It is not durable and often warps freely, and is one of the few woods that shrink endways. Mottled wood is valuable for panelling. *S.G.* ·53; *C.W.* 2; *E.* 2 m.; *C.* 1,000; *R.* 1,400; *S.* 100.

Larch

Larix decidua (Europe). Reddish brown. Moderately heavy, strong, very tough and durable for a softwood. Straight grain, fairly free from knots, resinous. Requires careful seasoning to avoid checks and warping. Used for outbuildings, fencing, etc. WESTERN LARCH, *L. occidentalis* (B. Columbia), has the characteristics and properties of European larch, but is of better quality and larger sizes, and is used for general construction, interior finishings, and floorings. There are other species, imported from Japan and Siberia, also see TAMARACK. *S.G.* ·55; *C.W.* 2; *E.* 1·4 m.; *C.* 1,000; *R.* 1,300; *S.* 90.

New Zealand Pines

These are excellent softwoods, with many of the properties and characteristics of kauri. They are generally marketed as Rimu. TOTARA, MATAI, and MIRO are species of *Podocarpus*; and RIMU, *Dacrydium cupressinum*. They are light brown with variegated streaks, fairly straight grain, easily wrought, but not durable. Figured wood is used for superior joinery as it polishes well, but exports are restricted. *S.G.* ·53; *C.W.* 2.

Pines

The pines form the biggest and most useful group of coniferous woods, and they are used for all kinds of carpentry and joinery. The better-known pines are described under PITCH-PINE, YELLOW PINE (white pine), and REDWOOD. The following are other important pines marketed in this country: AUSTRALIAN PINES include BUNYA PINE, *Araucaria Bidwilli*; CELERY TOP PINE, *Phyllocladus rhomboidalis*; HOOP PINE, *Araucaria Cunninghamii*; HUON PINE, *Dacrydium Franklinii*; and KING WILLIAM PINE, *Athrotaxis selaginoides*. These are imported from Tasmania, S.E. Australia, and Queensland. They are chiefly rich brownish woods, and only better and figured qualities are imported, and used for superior joinery, veneers, etc. The working qualities and characteristics are similar to New Zealand pines. CANADIAN PINES include JACK PINE, *Pinus Banksiana*, which has characteristics between those of yellow pine and redwood, but small sizes; LODGEPOLE PINE, *P. contorta*, is similar to Jack pine; PONDEROSA PINE, *P. ponderosa*, is also called western yellow pine, but it has a more pronounced grain, like redwood; RED PINE, *P. resinosa*, which is very similar to European redwood; SUGAR PINE, *P. Lambertiana* (California), and WESTERN WHITE PINE, *P. monticola*, are very similar to yellow pine. Southern U.S.A. provides several species included in pitch-pine. SOUTH AMERICAN PINES are PARANA PINE, *Araucaria brasiliana*, and CHILE PINE, *Araucaria imbricata*, which are more like Australian pines. SIBERIAN PINE, *P. cembra* (Manchurian yellow pine), has all the characteristics of yellow pine. There are also several S. European pines, but they are of little importance in the building trades.

Pitch-pine or Southern Pine

(South U.S.A.) This is the heaviest, strongest, and most resinous of the pines. It is golden yellow, with strong reddish summerwood, durable, shrinks greatly and slowly, and of large sizes. The best species is called LONGLEAF PINE, *P. palustris*. Other species are LOBLOLLY P.-PINE, *P. Tæda*; *P. echinata*, and *P. caribæa* (Honduras). In the U.S.A. the name pitch-pine is applied only to the inferior species *P. rigida*. Pitch-pine is used for heavy constructional work, and interior joinery to be varnished. It is not suitable for paint, due to the resin. The working

qualities depend upon the amount of resin and the unevenness of the grain. *S.G.* ·8 ; *C.W.* 2·5 ; *E.* 1·6 m. ; *C.* 1,200 ; *R.* 1,200 ; *S.* 120.

Podo

Podocarpus spp. (E. Africa). These are high-class softwoods, called yellowwood, with characteristics between those of yellow pine and redwood. They are pale brown, straight, fine, even grain, very easy to work, but require careful seasoning. The strength and durability are satisfactory for building purposes.

Redwood

Pinus Sylvestris (N. Europe, Siberia). This is now the standard name for the most-used building timber. It is known as red or yellow deal, Scots or Baltic fir or pine, and by various other names. It is yellow, with reddish markings, strong, stiff, durable, and resinous. The wood is pleasant and easy to work, and is used for all kinds of constructional work and exterior joinery, flooring, etc. See PINES. *S.G.* ·5 ; *C.W.* 1·75 ; *E.* 1·3 m. ; *C.* 720 ; *R.* 900 ; *S.* 90.

Sequoia or Californian Redwood

Sequoia sempervirens (U.S.A.). This is the largest known tree, and very large sizes of timber, free from defects, are obtainable. Owing to the rapid growth the wood is coarse-grained, and it is not appreciated in this country. Its brittleness makes it unsuitable for tenons. The colour is dull brown, with brighter markings, and it is used for panels, shelving, etc. It is easily wrought, but the end grain is difficult to work smooth. It is strong for its weight when in bulk, durable and stable, and is extensively used for heavy structural work. *S.G.* ·35 ; *C.W.* 1·5 ; *E.* 0·8 m. ; *C.* 900 ; *R.* 900 ; *S.* 80.

Spruce

Picea spp. (Europe, Canada, U.S.A.). It is difficult for the woodworker to distinguish between fir and spruce, and all the species are *white deal* to him ; but the timber merchant now distinguishes *fir*, *spruce*, and *whitewood*. Spruce is white with yellowish markings, lustrous, soft, light, very strong and elastic for its weight, but not durable. It has an even texture and is easily wrought, and is extensively used for cheaper constructional work, kitchen fitments, and shelving, because of its clean appearance, flooring, scaffolding, etc. There are five species imported from Canada : white, red, black, Engelmann, and Sitka. The first three are marketed as *Canadian spruce*, and are from Eastern and Northern Canada and U.S.A. White spruce is the best known, because of the larger sizes. Engelmann spruce is very similar to white spruce, but is from the west. SITKA or SILVER SPRUCE, *Picea sitchensis* (W. Canada), is the best, strongest, most elastic, and most esteemed of spruces.

Owing to its superior qualities and larger sizes it is in great demand for aircraft. Also see WHITEWOOD. *S.G.* ·4; *C.W.* 1·25; *E.* 1·2 m.; *C.* 800; *R.* 1,100; *S.* 85.

Tamarack

Larix laricina (Canada), is one of the strongest softwoods of E. Canada. It is very similar to western larch, but not so good, and is little used in building. See LARCH.

Whitewood

Picea Abies or *Abies alba* (N. and C. Europe). This is one of the best-known softwoods used in building, owing to its cheapness, plentiful supplies, and easy-working qualities. The qualities vary considerably, but it is inferior to silver spruce. The term white deal has been used in the building trades for all species of *Abies* and *Picea*, and it is only recently that the distinctions have been made. See FIR and SPRUCE for properties and characteristics. Also see HARDWOODS for American whitewood.

Yellow Pine

Pinus Strobus (Canada). Also called white pine, Weymouth, and Quebec pine. Yellow pine is the favourite wood of the joiner, owing to its pleasant and easy-working qualities and its stability. It is soft, light, very uniform and even in grain and texture, and is the most stable softwood, but it is not very durable. Owing to its admirable qualities, and large sizes free from defects, the demand has forced up the price, so as to confine the use to first-class interior joinery. Yellow pine can be distinguished from other pines by the finely distributed resin ducts. There is practically no difference between *P. Strobus*, *P. cembra*, and *P. monticola*. See PINES and REDWOOD. *S.G.* ·34; *C.W.* 1; *E.* 1·1 m.; *C.* 800; *R.* 900; *S.* 85.

Yellowwood

Podocarpus coriaceus (Honduras). Also called yacca. An excellent softwood, but little used in building. See NEW ZEALAND and AUSTRALIAN PINES, with which it has many characteristics in common.

Yew

Taxus baccata (Europe). This is more like a hardwood than a softwood, and is not appreciated in this country. It is pale red, lustrous, hard, heavy, strong, tough, elastic, very durable, and is not resinous. The smooth, uniform texture and handsome grain and figure make it valuable for fancy articles. *S.G.* ·8; *C.W.* 4.

HARDWOODS

There is a far greater variety of hardwoods than softwoods, but few of them are used as constructional timbers, and most of them are cabinet woods rather than joinery woods, although the number coming within the scope of the joiner is continually increasing.

American Whitewood

See BASSWOOD, CANARY WOOD, and COTTON WOOD.

Ash

Fraxinus excelsior (Europe). Whitish grey with yellow markings. Very tough and elastic, with straight grain and coarse texture. It is too valuable for agricultural and gymnastic equipment, tools, aircraft, etc., to be used in building, except figured woods, which are generally used as veneers. Ash polishes well, bends easily, and is not difficult to work. *S.G.* ·65 ; *C.W.* 2·8.

There are several other Canadian and European species, but they are not so good as the above, except Canadian white ash. They are called black, red, blue, green, and white ash. ALPINE ASH, *Eucalyptus gigantea* (Australia), and WHITE MOUNTAIN ASH, *Euc. regnans* (Tasmania), resemble oak rather than ash. They are used for superior joinery, flooring, etc. They are pale brown, fairly light and hard, with distinct rings and beautiful figure, easy to season, and not difficult to work. *S.G.* ·65 ; *C.W.* 3·5. JAPANESE ASH or TAMO is used for superior joinery.

Bagac. See TEAK.

Balsa

Ochroma lagopus (Trop. America). Yellowish white. Very light, soft, elastic, buoyant, and difficult to split. It is the lightest wood imported into this country, and is used only for insulating purposes and where lightness is the chief consideration. *S.G.* 0·1.

Basswood

Tilia glabra (Canada and U.S.A.). The lime or linden tree. There are several species, but they are all marketed as American whitewood. The wood is greyish white to yellowish, with fine texture, and uniform, even grain, and obtainable in large sizes. It is light, soft, not durable, easily wrought, and stains and polishes well, but it shrinks and warps freely. Used for joinery, panelling, carving, etc. *S.G.* ·6 ; *C.W.* 2.

Baywood. See MAHOGANY.

Beech

Fagus sylvatica (Europe). Light reddish brown. Moderately hard, heavy, with fine, even texture and close grain, but not durable. The

medullary rays show as darker flecks. It is used for tools, bentwood, and for purposes where resistance to wear is important. *S.G.* ·8 ; *C.W.* 3.

There are several Australian woods (*Nothofagus spp.*, or Antarctic beech), esteemed for high-class joinery. See MYRTLE. SOUTHLAND BEECH, *Nothofagus sp.*, also called New Zealand, or silver, beech, is similar to European.

Birch

Betula alba (Europe). Common, silver, or white, birch. Light brown, lustrous, fairly hard and strong, even and fine grain, and retains sharp arrises, not durable. Stains and polishes well. Used for fittings, handrails, turnery, and figured wood for panels and veneers. There are other species from Canada and Europe, but they differ little from the above. RED or CHERRY BIRCH, *B. lenta* (Canada), is also called Mountain mahogany. *S.G.* ·7 ; *C.W.* 3·5.

Black Bean

Castanspernum australe (E. Australia). Dark brown, with variegated streaks and mottles, and lustrous. Hard, heavy, strong, durable, and resists insects. Straight grain, close texture, large sizes, and a good insulator. It is not difficult to work, but requires careful seasoning as it shrinks and warps freely. Used for superior joinery, electrical fittings, etc. *S.G.* ·8 ; *C.W.* 3·5.

Blackwood

Acacia melanoxylon (Australia, Tasmania). Reddish brown to nearly black, with variegated streaks, and lustrous. It is hard, strong, with rather coarse, even texture. Fairly difficult to work when with interlocked and wavy grain. Fiddleback is considered one of the most beautiful woods. Used for high-class joinery and veneers, and plain wood for superior flooring. *S.G.* ·8 ; *C.W.* 3·5. BOMBAY BLACKWOOD, *Dalbergia latifolia*, Indian rosewood, or shisham. Purplish or nut-brown, with variegated markings, fragrant and lustrous. Hard, heavy, strong, durable, and resists insects. Ribbon grain gives beautiful wood for high-class joinery and veneers. Difficult to work, due to secretion and cross-grain. *S.G.* ·85 ; *C.W.* 4. E. AFRICAN BLACKWOOD, *D. melanoxylon*, has many of the properties of ebony, for which it is used as a substitute. W. INDIES BLACKWOOD is a species of ebony.

Camphor Wood

Cinnamomum spp. (E. Asia). This belongs to the laurel family, and there are several species. Yellowish, olive, to orange-brown, with darker streaks. Fairly light and soft, fragrant, smooth, and not difficult to work. Sometimes with interlocked grain and pith flecks. Used for better-class joinery. *S.G.* ·6 ; *C.W.* 2·5. BORNEO CAMPHOR, *Dryo-*

balanops sp. Called kapur, keledan, etc. Brownish red, odorous, fairly hard, heavy, tough, and durable. Close texture, interlocked grain. It resembles mahogany when finished, but is often difficult to work smooth. Used for high-class joinery, flooring, etc. *S.G.* ·75 ; *C.W.* 3·5. KENYA CAMPHOR, *Ocotea sp.* Called muzaiti. Pale yellow, seasoning to nut-brown. Also used for superior joinery. *S.G.* ·6 ; *C.W.* 3·5.

Canary Wood

Liriodendron tulipifera (U.S.A.). The colour of this wood varies from yellowish to greenish in the same piece. It is soft, light, with even texture and uniform grain, and not durable. It is very easy to work, but shrinks and warps freely. Stains and polishes well. Used for joinery, carving, etc. Usually marketed as American whitewood. *S.G.* ·45 ; *C.W.* 1·5.

Cedars

These are species of *Cedrela*, which belongs to the mahogany family. (Also see SOFTWOODS.) The chief supplies are from Central America, generally called Spanish cedar, and from India and E. Indies, called toon. HONDURAS or SPANISH CEDAR, *Cedrela odorata* or *C. mexicano* (C. America and W. Indies). Light red, fragrant, durable, and stable. It is easy to work, with the characteristics of a soft mahogany, and used for high-class joinery. *S.G.* ·6 ; *C.W.* 2. Also see TOON, SAPELE, and SERAYAH.

Chestnut

Castanea sativa (Europe). Called sweet or Spanish chestnut. This wood resembles and has many of the properties of soft, plain, oak, but it is coarser-grained and without silver grain, and is a good substitute for the milder species of oak. It is easy to work and season, obtainable in large sizes without defects, and also used for heavy constructional work and timber foundations because of its durability. *S.G.* ·62 ; *C.W.* 3 ; *E.* 1·2 m. ; *C.* 1,000 ; *R.* 1,200 ; *S.* 100. INDIAN CHESTNUT, *Castanopsis sp.*, is light greyish brown, with interlocked grain, and shows a fine silver mottle when polished. It has many of the characteristics of European chestnut, but is more uneven in texture and more difficult to work smooth, and is used for better-class joinery. MALAY CHESTNUT is similar to Indian, and is called berangan.

Chuglum

Terminalia spp. (India). This is marketed as white chuglum and Indian silver greywood, or black chuglum. The latter is the product of false heart, and only found in occasional trees. Some writers reverse the terms white and black. The wood is olive-grey with variegated streaks, lustrous, smooth ; and silver greywood, which is olive-brown, is highly decorative and used for superior finishings and veneers. Straight-grained

wood is used for flooring, etc. Chuglum requires careful seasoning, but it is not difficult to work although liable to pick up. *S.G.* ·6 to ·8 ; *C.W.* 3.

Cottonwood

Populus spp. (N. America). This includes several species, known as necklace poplar, balsam poplar, etc. They are all usually marketed in this country as American whitewood. The working qualities are very similar to canary wood.

Crabwood

Carapa guianensis (B. Guiana). Mahogany family. Also called carapa. This is an excellent wood if quarter-sawn and carefully seasoned, but owing to careless exporting and conversion it has lost favour. The wood is reddish brown ; moderately hard, heavy, durable, and strong. It has a slightly open grain, and ribbon grain is apt to pick up, making it fairly difficult to finish smooth. It resembles mahogany when polished. *S.G.* ·7 ; *C.W.* 3·5.

Ebony

Diospyros spp. and *Maba spp.* These trees grow throughout the tropics, and there is great variation in the woods from the different species and countries. The colour varies from black to variegated black, brown, and green. It is one of the hardest, heaviest, and toughest of woods, and difficult to work. It is not used in joinery except to provide decorative effect by contrast with other woods, but it is very valuable for other purposes. Black ebony is very scarce, and of small sizes, hence all kinds of hard, dense woods are dyed in imitation. The wood is sold by weight, in billets. *S.G.* 1·1 ; *C.W.* 5.

Elm

Ulmus campestris (Europe). There are several English species, all marketed as English or common elm. It is reddish brown, moderately hard, heavy, very tough and difficult to split, and shrinks and warps freely unless scientifically seasoned. The difference in spring- and summerwood gives handsome grain in slash-sawn wood. It is very durable in wet or dry conditions, but not both. Used for all purposes and increasing in favour for joinery work. Difficult to work due to knots, irregular growth, and warping. *S.G.* ·6 ; *C.W.* 3·5 ; *E.* 1·3 m. ; *C.* 900 ; *R.* 1,300 ; *S.* 110. CANADIAN ELM includes several species, varying in quality, some better and some worse than English, but they form the bulk of our supplies. CHINESE ELM is a beautiful wood in colour and texture, and highly esteemed.

Eng or In

Dipterocarpus tuberculatus (India, Burma). Reddish brown, darkening with exposure, fragrant, resembles gurjun. Hard, heavy, strong,

fairly durable, large sizes. Straight grain, difficult to season, and stains with corroding iron. A gum secretion makes it difficult to work. Used for superior joinery, flooring. *S.G.* ·84 ; *C.W.* 4·5.

Eucalyptus

This is the most important Australian tree. There are over three hundred species, from shrubs to the largest known hardwoods, that rival the sequoia in size. The characteristics and properties vary considerably, but the commercial woods are mostly very hard, heavy, strong, tough, durable, and chiefly fire-resisting. They are marketed as blackbutt, coolibah, gimlet, grey box, gum, ironbark, jarrah, karri, mallee, mallet, marri, maiden, merrit, messmate, morrell, mountain ash, peppermint, red box, red mahogany, redwood, stringybark, tallow wood, Tasmanian oak, tingle-tingle, tuart, wandoo, white ash, white mahogany, woollybutt, wormwood, yate, yellow box, yorrell. See ASH, JARRAH, KARRI, TASMANIAN OAK.

Gaboon

Aucoumea Klaineana (W. Africa). Gaboon mahogany or okoumé. Resembles a soft African mahogany, and used extensively for plywood, laminwood, and as a core for veneering. See MAHOGANY.

Greenheart

Ocotea Rodioei (*Nectandra R.*) (British Guiana). Olive-green, darker streaks. Very hard, heavy, strong, and durable. The best timber for resisting marine insects. Used for piling, harbour work, brewers' stagings, etc. *S.G.* 1 ; *C.W.* 5·5 ; *E.* 1·7 m. ; *C.* 1,500 ; *R.* 2,000 ; *S.* 120.

Gum

The name applied to several species of eucalyptus. They are excellent timbers, but little imported into this country. Also see RED GUM.

Gurjun

Dipterocarpus spp. (India, Burma). Reddish brown. Fairly hard, heavy, strong, and durable. Some interlocked grain, but not very difficult to work. Does not polish well. Used chiefly for flooring. *S.G.* ·75 ; *C.W.* 4.

Haldu

Adina cordifolia (India, Burma). Yellow to light reddish brown. Moderately hard, durable, and strong. Fine, even texture, with some interlocked grain. Resembles satinwood. Not difficult to work, and carves and polishes well. Used for superior joinery. *S.G.* ·68 ; *C.W.* 3.

Hickory

Carya spp. (N. America). Includes butternut, shagbark, mockernut, and piquit. Superior to ash for sports equipment, shafts, etc. Not used in joinery. *S.G.* ·7 ; *C.W.* 4 ; *E.* 2 m.

Indian White Mahogany

Canarium euphyllum (Andaman I.). Called white dhup. Pale yellow, lustrous, smooth. Light, soft, not durable. Interlocked grain. Stains and polishes well. Used for superior joinery. *S.G.* ·5 ; *C.W.* 2·75.

Iroko

Chlorophora excelsa (W. Africa). Called odum, mvule, Nigerian teak. Dark brown, streaked, and lustrous. Fairly hard and heavy. Strong and durable. Rather coarse, interlocked grain, and difficult to work. Substitute for teak. *S.G.* ·65 ; *C.W.* 4·25.

Ironwood

There are nearly one hundred different woods called ironwood. They are all very hard, heavy, and difficult to work ; and few are used in building. The best known are billian, ekki, gangau, ipil, mesquite, melkhout, pynkado.

Jarrah

Eucalyptus marginata (W. Australia). Reddish brown, often with black flecks. Hard, heavy, strong, and durable. Requires careful seasoning ; and interlocked grain difficult to work smooth. An excellent wood for most purposes, and very large sizes. Used for flooring, wood blocks, superior joinery, etc. *S.G.* ·88 ; *C.W.* 3·75 ; *E.* 2 m. See KARRI.

Karri

Euc. diversicolor (W. Australia). Similar to jarrah, but paler, stronger, and not so durable. Rather coarse, porous grain ; and interlocked. Used for structural work, bentwork, and as jarrah. *S.G.* ·92 ; *C.W.* 4·25 ; *E.* 2·5 m. ; *C.* 1,200 ; *R.* 1,600.

Kokko

Albizzia Lebbek (Burma, Andaman I.). Dark brown, darker markings. Hard, brittle, fairly heavy, and durable. Interlocked and wavy grain. Beautiful figure for interior joinery. Requires careful seasoning. Not difficult to work, but rather woolly texture. *S.G.* ·65 ; *C.W.* 3.

Lacewood

Selected quarter-sawn wood with wavy grain, from the plane tree. See SYCAMORE and SILKY OAK.

Lauan

Dipterocarpaceæ family (Philippines). Lauan includes a number of different species, hence there is great variation in the woods marketed in this country. RED LAUAN, *Shorea negrosensis*, called Philippine mahogany. Dark red, slightly lustrous, with ribbon grain. Coarser and more liable to warp than mahogany, but used for the same purposes. *S.G.* ·55 ; *C.W.* 3·5. WHITE LAUAN, *Pentacme contorta*. Pinkish colour, otherwise very similar to red lauan.

Laurel

Terminalia tomentosa (India). Dark brown, darker streaks, lustrous. Hard, heavy, strong, and fairly durable. Close, firm texture, interlocked wavy grain. Requires careful seasoning and difficult to work. Highly esteemed for superior joinery and veneers. *S.G.* ·88 ; *C.W.* 5. There are many other laurels, but they are of little commercial importance in this country.

Lignum Vitæ

Guaiacum officinale (C. America). Greenish black. Extremely hard, heavy, tough, and durable. Very difficult to work. Sold by weight, and used for machine parts, tools, bowls, fancy articles. *S.G.* 1·1 ; *C.W.* 6.

Lunumidella

Melia dubia. Ceylon mahogany. Like *toon*, and used for superior joinery.

Mahogany

There is a great variety of woods sold under this trade-name, usually distinguished by the source of origin, hence there is great variation in quality. There are only three genera recognised as mahogany : *Swietenia*, *Khaya*, and *Entandrophragma*. CUBAN, *Swietenia spp.* (W. Indies). Rich brown-red, lustrous, with chalky deposit. Hard, heavy, durable, and very stable. The most popular wood for superior joinery owing to the beautiful figure, finish, and ease of working and stability, but supplies are scarce. *S.G.* ·8 ; *C.W.* 3·5. HONDURAS (C. America) is the same genus as Cuban, but is from the mainland. It is golden red, softer and lighter than Cuban, and at one time was distinguished as *baywood*. *S.G.* ·6 ; *C.W.* 3. W. AFRICAN, *Khaya spp.* There are several varieties, named after the port of shipment, etc., as Benin, Lagos, Half-Assinie, Axim, Secondi, Grand Bassam, and Dubin. Many of them are beautiful woods and very similar to Honduras, and form the bulk of our supplies. AUSTRALIAN, *Dysoxylum sp.* This is an excellent wood, but not a mahogany. It is also called rosewood. Several species of eucalyptus are also described as mahogany. BORNEO, *Calophyllum sp.* This also has many of the characteristics of mahogany, and is an excellent wood for

superior joinery. RHODESIAN, *Copaifera sp.*, is very hard-wearing and stable, and is used for flooring, etc.

There are several tropical American woods wrongly described as mahogany: crabwood, mahoe, espavé, etc. See GABOON, SAPELI, THITKA, TOON, LAUAN, and INDIAN WHITE MAHOGANY.

Maple

Acer saccharum (Canada). Rock or sugar maple. Creamy white with reddish tinge and darker markings, sometimes brown heartwood. Smooth, lustrous, hard, strong, stiff. Fairly heavy and not durable. Close, even grain. Curly figure and bird's eye highly esteemed for decorative work. Seasons well, not difficult to work, and polishes well. *S.G.* ·66; *C.W.* 2·5; *E.* 1·6 m.; *C.* 1,100; *R.* 1,500; *S.* 120. Japanese maple is very similar to the above.

Maple Silkwood

Flindersia sp. (Queensland). Flesh-pink colour, lustrous, with ribbon and ripple figure. The wood is hard, tough, and strong, but is chiefly used for superior joinery and veneers. Fuming turns it grey colour. *S.G.* ·62; *C.W.* 4.

Meranti

Shorea sp. (Malay). Very similar to red lauan and red seraya.

Mora

Mora excelsa (B. Guiana). Several varieties. Chestnut-brown, variegated streaks. Very hard, heavy, tough, strong, and durable, with close grain. Many of the properties of greenheart, for which it is used as a substitute. *S.G.* 1; *C.W.* 6.

Myrtle, Tasmanian

Nothofagus sp. Salmon-pink to brown. Similar to English beech, but without the large rays. Stains and polishes well, and used for superior joinery. *S.G.* ·8; *C.W.* 4. CALIFORNIAN MYRTLE, laurel family, is light brown with beautiful figure, and is very resilient. Used for dance floors and furniture.

Oak

Quercus Robur and *Q. sessiliflora* (Europe). English oak. Rich, light brown. Hard, heavy, very strong and durable. Large rays give beautiful silver grain. May be fumed, polished, or limed. Used for all purposes. This is the best of the oaks, of which there are about three hundred species, but it is difficult to work due to knots, irregular grain, and hardness. *S.G.* ·9; *C.W.* 4; *E.* 1·5 m.; *C.* 1,200; *R.* 1,500; *S.* 110. AUSTRIAN or EUROPEAN OAK is similar to English but milder, easier to

work, and only better qualities are imported. Also called *wainscot oak*, which simply means quarter-sawn. AMERICAN OAK. There are several species, the most important of which are red oak, *Q. borealis*, and white oak, *Q. alba*. They are not so strong, hard, or durable as English, but easier to work, especially red oak, and with fewer defects. JAPANESE OAK is very uniform in colour and texture and free from defects. Mild and easy to work, like American red oak. AFRICAN OAKS. These are not oaks, and are often called African teak and red ironwood. SILKY OAK, *Carwellia sp.* (Queensland). Also called lacewood. Pale pink, lustrous, with beautiful silver grain. Used for superior joinery and veneers. *S.G.* ·6 ; *C.W.* 2·75. SHE OAK, *Casuarina sp.*, has many of the characteristics of oak and is esteemed for superior joinery. TASMANIAN OAK is a species of eucalyptus, and is used for flooring and joinery.

Obeche

Triplochiton scleroxylon. Nigerian whitewood. Creamy white, soft, light, with interlocked grain that gives a stripy effect. Open, uniform texture and fairly stable. Seasons and works easily, and polishes well. Used for joinery, matchboarding, etc. *S.G.* ·4 ; *C.W.* 1·75.

Padauk

Pterocarpus spp. (India, Burma, Andaman I.). Deep crimson with darker to black stripes. Strong, durable, elastic, stable, fairly hard, and heavy. Beautiful figure with interlocked grain. Fairly difficult to work smooth. Highly esteemed for superior joinery, especially Andaman wood. African padauk is very similar to Andaman. *S.G.* ·78 ; *C.W.* 3·25.

Poplar

Populus (Europe, N. America). Several species. Brownish white, soft, light, not durable. Uniform, fine close grain. Smooth, does not splinter, but shrinks greatly. Easily wrought. Often decorative, due to the sinkers of mistletoe. See COTTONWOOD.

Purpleheart

Peltogyne spp. (B. Guiana). Amaranth or violetwood. Brown, to purple on exposure. Very hard, heavy, tough, strong, durable, and shock-resisting. Smooth, fine, wavy and roey grain. Used for superior joinery, and where strength and shock-resistance are required. *S.G.* 1 ; *C.W.* 4·5.

Pyinkado

Xylia dolabriformis (India, Burma). Acle or ironwood. Reddish brown. Very hard, heavy, and strong and durable. Close, wavy grain with fine rays. Beautiful figure. Difficult to season and work. Used for structural work and superior joinery, etc. *S.G.* 1·1 ; *C.W.* 5·5.

Pyinma

Lagerstræmia hypoleuca (Andaman I.). Light reddish brown. Hard, heavy, durable, strong, and elastic. Seasons well and fairly easy to work. Polishes well. Used for second-class joinery, and figured wood for veneers. *S.G.* ·8 ; *C.W.* 2·75.

Red Gum

Liquidambar styraciflua (U.S.A.). Hazel pine or satin walnut. Light to dark brown with variegated markings. Lustrous with beautiful figure. Variable in weight and hardness, not strong or durable. Smooth, fine, even grain. Easy to work and polishes well. Used for furniture, veneers, etc. *S.G.* ·5 to ·65 ; *C.W.* 2.

Rosewood

Dalbergia latifolia (India). Bombay blackwood. Dark purplish brown, darker markings. Heavy, very hard, durable, and strong. Fine, even texture with ribbon grain. Seasons fairly well, and rather difficult to work. Used for high-class joinery, parquet floors, veneers, etc. *S.G.* ·8 ; *C.W.* 4. HONDURAS ROSEWOOD is very similar to Indian. There are many woods called rosewood that are not species of *Dalbergia*, but because they have similar characteristics, or because of their fragrance.

Sapele Mahogany

Entandrophragma spp. (Nigeria). Gold Coast cedar. Pinkish to reddish brown, with lustrous, ribbon-stripe figure. Fairly hard and strong, but not durable. Requires careful seasoning, and liable to pick up in working. Characteristics and uses of other African mahoganies. *S.G.* ·6 ; *C.W.* 3·5. There are several species from E. and W. Africa, but they all have similar characteristics and properties.

Satin Walnut. See RED GUM.

Satinwood, East Indian

Chloroxylon swietenia. Golden yellow to dark brown, very lustrous. Very hard, heavy, durable, and strong. Ribbon grain and mottle give beautiful figure. Difficult to work, and requires careful seasoning. Highly esteemed for superior joinery and veneers. *S.G.* 1 ; *C.W.* 5. ANDAMAN, *Murraya exotica*, NIGERIAN, *Distemonanthus sp.*, and W. INDIES SATINWOOD, *Zanthoxylum spp.*, are similar to the above, and esteemed for high-class work.

Serayah, Red

Shorea spp. Borneo red cedar or mahogany. Similar to red lauan and meranti. WHITE SERAYAH, *Parashorea spp.*, Borneo white cedar. Both red and white serayah are like a mild, plain mahogany, for which they are

excellent substitutes. The red is favoured because of the darker colour and slightly finer texture. *S.G.* ·55 ; *C.W.* 3·5.

Silver Greywood. See CHUGLUM.

Sycamore

Acer pseudo-platanus. Great maple or Scotch plane. Yellowish white, lustrous. Fairly hard, heavy, and stable, but not durable. Fine, uniform grain and texture. The rays and wavy grain, when quarter-sawn, give a valuable decorative wood which, after treatment, is known as greywood, harewood, lacewood, and weathered sycamore. Stains and polishes well. Used for kitchen utensils, turnery, and decorative joinery. *S.G.* ·62 ; *C.W.* 3·5. NIGERIAN SYCAMORE, *Scottelia sp.*, is a similar wood.

Teak

Tectona grandis (India, Burma). Moulmein and Rangoon teak are most esteemed. Light brown, to dark brown on exposure. Hard, heavy, stable, very strong, and durable. Straight grain, rather coarse texture, but smooth. Resists fire and marine insects. Easy to work green, but difficult when seasoned due to secretion. Used for windows, doors, flooring, and superior joinery with oil or polish finish. *S.G.* ·7 ; *C.W.* 4·5 ; *E.* 2·2 m. ; *C.* 1,800 ; *R.* 2,000 ; *S.* 120. RHODESIAN, *Baikiaea sp.*, NIGERIAN (iroko), PHILIPPINE (bagac or yacal), and BORNEO TEAK, *Hopea spp.*, are all excellent woods and used as substitutes for the above because they have similar properties.

Thitka

Pentace burmanica. Burma mahogany. Has the appearance and characteristics of mahogany, and used for the same purposes. *S.G.* ·7 ; *C.W.* 2·5.

Toon

Cedrela toona. Indian or Moulmein cedar or mahogany. Grey, seasoning to mahogany colour. Light, fairly soft, fragrant, durable, and stable, but not strong. Close grain and easily wrought. Beautifully veined, and polishes well. Used for superior joinery, furniture, etc. *S.G.* ·5 ; *C.W.* 2.

Walnut, Black

Juglans regia (S. Europe, Persia, and U.S.A.). Rich dark brown, darker veins, lustrous. Hard, heavy, strong, stable, but brittle. Fine, even texture and polishes well. Beautiful wood for high-class joinery, especially when striped. The American wood is stronger, but the European is often artificially burred, more decorative, and is marketed as Circassian, Italian or Ancona, and French. AUSTRALIAN, *Endiandra sp.*,

is called Queensland or Oriental walnut. It closely resembles walnut, and is used for the same purposes, chiefly as veneers. JAPANESE and MANCHURIAN, *Juglans sp.*, is milder than *J. regia* and not so decorative. NIGERIAN, *Lovoa klaineana*, Benin, or W. African walnut, is an excellent wood, but resembles mahogany except for the dark gum streaks. WHITE WALNUT, *J. cinera*, butternut, is inferior to black walnut, but is stained as a substitute.

White Bombway

Terminalia procera (India, Andaman I.). Brownish with darker streaks. Very similar to black chuglum. Straight and interlocked grain. Fairly light, hard but not durable. Smooth, and not difficult to work. Stains and polishes well. Used for better-class joinery. *S.G.* ·65 ; *C.W.* 3·5.

White Dhup. See INDIAN WHITE MAHOGANY.

Whitewood. See OBECHE, and AMERICAN WHITEWOOD.

Special notes on British Empire Hardwoods are given on pages 4 to 16.

VENEERS

The use of veneers in joinery work is continually increasing, as very choice woods are obtainable only in this form owing to their cost and scarcity. Within recent years there has been great improvement in the machines for conversion and in the quality of glues, so that the highest class of joinery is often veneered in modern work. There are three methods of converting the wood, or *flitch*, into veneers : sawing, slicing, and rotary-cutting, or peeling.

Sawing

This method is wasteful, and is adopted only for the choicest, highly figured woods such as burrs, crotch, very curly and very hard woods, or those that will not slice cleanly. A large, thin-gauge saw with fine teeth is used. The saw is built up in segments and may be up to 18 ft. diameter. Sawn veneers are seldom less than $\frac{1}{20}$ in. thick.

Slicing

This is the usual method of converting decorative woods because it is economical. The process is similar to removing a shaving with a plane. It is used for woods requiring a radial cut for the figure, such as ribbon grain, silver grain, etc. The logs are quartered, and cut to length, into flitches, about 6 ft. 6 in. long. The flitches are steamed, or boiled, and then fixed in the frame of the machine.

In some machines the knife slides over the wood, like the action of a plane, and in others the flitch slides horizontally or vertically on to the fixed knife. The knife edge meets the wood diagonally to give a clean cut. After each slice there is an automatic movement of the carriage equal to the thickness of the veneer, and the operation is repeated. The knife should cut towards the heart to avoid plucking, or *distressing*, the grain. Experience has proved that the thickness of the veneer should be about $\frac{1}{28}$ in. to avoid glue percolating through when veneering, and to avoid distressing the grain through slicing too thick. The machines, however, can slice from 4 to 140 sheets to the inch.

Rotary Peeling

The round log is cut to length and steamed as for slicing. It is fixed in the machine, which acts very much like a lathe. The log is forcibly rotated against the fixed blade, which turns off a continuous sheet of veneer, like unrolling linoleum. The thickness may be from $\frac{1}{80}$ in. to $\frac{3}{8}$ in. This method is the most economical, and is adopted for woods of uniform grain, veneers for plywood, wood with strongly contrasting spring- and summerwood, bird's eye, etc.

Half-rotary Slicing

This method is a compromise between peeling and slicing. The flitches, or segments, are quarter-sawn as for slicing, and rotate against the knife so that a partly radial cut is obtained. It is not so economical as peeling, but it obtains the ribbon and silver grain in the veneers.

PLYWOOD

Plywood consists of layers of veneer, or plies, glued together, with the grain of the plies alternating in direction. This produces a board many times stronger than ordinary wood of the same thickness, and counteracts shrinkage. In good qualities waterproof glue is used, and in some cases the plies are stitched together in addition to gluing. British plywood is usually registered under a trade-name, as Apco, Consuta, Venesta, etc.

Sizes

The number of plies varies according to the quality and thickness, from *three-ply* to as many as thirty-six alternating laminations ; and the thickness varies from less than $\frac{1}{32}$ in. to over 1 in. The face measurements are given in feet or inches, but the thickness is stated in millimetres.

Standard sheets are 60 in. by 60 in. or 60 in. by 48 in., the first dimension denoting the direction of the grain of the face ply. The manufacturers, however, prepare *special cut sizes* to suit particular trades and requirements. Three-ply is usually from 3 mm. to 6 mm. thick, five-ply from 6 mm. to 12 mm., but above 9 mm. thick there may be any number of plies, as stated above.

Qualities

Ordinary plywood is invariably made from rotary-cut veneers, but the better qualities may be faced with sliced or even sawn veneers. Most of the plywood, except the best qualities, is imported. The woods used vary with the different countries. Plywood from Europe and Japan is chiefly of alder, birch, ash, oak, and redwood. Australian plywood is usually of hoop pine, silky oak, maple, and walnut. N. American plywood is chiefly of Douglas fir, gum, maple, or as the European.

The qualities are graded according to the knots and other defects in one or both faces as : *A A*, *A*, *A A/BB*, *B*, *BB* ; and gaboon plywood, which is imported from the Continent, as *crown*, 1 *star*, 2 *star*, and 3 *star*.

Facings

Special qualities of plywood may be faced with almost any kind of figured veneer, with the cores usually of poplar, basswood, aspen, spruce, or pine, and are known as *built-up stock*. When ordinary plywood is veneered later with superior wood it is known as *veneered stock*. Metal-faced plywood is manufactured in panels up to 40 ft. long, with facings of stainless steel, galvanised iron, copper, or aluminium. Other proprietary types are faced with bakelite or other phenol or lactic compounds.

Laminwood

This is a development of plywood, but the core consists of strips of wood instead of veneers. It is a thick, compound board, consisting of a built-up core veneered on both sides. The strips forming the core are glued together and run at right angles to the grain of the face veneers. There are several variations in the arrangement of the core, and special names, as Blockboard, Battenboard, etc., are given to the boards, but they are all arranged to prevent shrinkage, and to give a stiff, stable board. The sheets may be obtained up to 8 ft. wide, 20 ft. long, and $1\frac{1}{2}$ in., or more, in thickness.

See also pages 465 to 477 for further information on all types of plywoods.

LIMES, CEMENTS, AND MORTARS

LIME was once one of the most important of building materials, but its use is tending to become restricted on account of the employment of cement and the different makes of gypsum plasters that are to-day on the market. These substitutes are justly popular, on account of their more scientific manufacture and resulting standardised composition, which renders them easier to employ on modern constructional work where large quantities of material are mixed by mechanical means. Nevertheless, many builders of experience still hold that lime possesses a number of valuable qualities which up to the present have not been reproduced in other materials.

Lime Manufacture

To understand the way to use lime, it is necessary also to know the method by which it is manufactured. Any natural form of calcium carbonate will produce lime when burnt, and the most common substances which contain it are chalk, limestone, marble, and marl.

Building lime is mostly manufactured from quarried limestone or chalk. The material is broken up and burnt in kilns by means of coal, coke, or other fuel. The chemical process consists in dividing up the calcium and magnesium carbonates by means of heat, and driving off the carbon dioxide gas produced in the process.

To burn limestone requires a temperaure of at least 900° C., which produces a bright red glow. The chemical change, $Ca\,CO_3 = CaO + CO_2$, does not take place instantaneously ; the carbon dioxide is given off slowly, and must be allowed to escape easily. When the CO_2 has been liberated, the calcium oxide, CaO, is allowed to cool, and this material, which has the appearance of friable lumps of stone or a white dust, is known as quicklime.

Composition of Lime

In England the composition of a good quicklime has been analysed as follows :—

Calcium oxide	93·2 per cent.
Magnesium oxide	·3 ,, ,,
Silica	·8 ,, ,,
Iron oxide and alumina	·6 ,, ,,
Water, etc.	5·1 ,, ,,
	100

In some countries, high-magnesium limestones are burnt for lime, and the magnesium-oxide content rises to as high as 43 per cent. of the whole; nevertheless, the lime produced from these dolomite stones has proved an excellent building material.

When water is added to quicklime it immediately becomes hot, swells to nearly twice its original bulk, and finally falls apart into powder. If more water is added until the mass becomes a pulp, it is known as lime putty.

Slaking Lime

If slaking begins in less than five minutes the lime is known as *quick-slaking* or *fat* lime; if between five and thirty minutes it is called *medium-slaking*, but if no action takes place for half an hour it is called *slow-slaking* or *lean* lime. Quick-slaking lime should be just covered with water to begin with, and the mass carefully watched. At the slightest appearance of steam more water should at once be added, and the heap hoed over with the special hoe.

Medium-slaking should have water added so as half to cover the mass, and a little more poured on from time to time to prevent steam escaping and the mass becoming dry and crumbly.

Slow-slaking lime should be thoroughly wetted at the outset, and then be allowed to stand until the slaking action begins. Water should be added sparingly from time to time, but not in sufficient quantities to over-cool the mass, and in cold weather hot water should be employed. The lime should not be hoed until nearly slaked, as it is necessary to retain the heat as much as possible.

Avoidance of Air Slaking

There is no practical advantage in separating the large lumps of quicklime from the powder before use. The only objection to the powder is the difficulty of discriminating it from air-cooled lumps, and it has been pointed out that the large lumps are probably less well burnt than the powder, being over-burnt on the outside with an under-burnt core. Air slaking, due to the lime absorbing moisture from the air, tends to weaken the setting properties of the material, as the lime has absorbed carbon dioxide from the air as well as moisture, and has therefore begun to carbonate. A good test to determine whether air slaking has taken place in a batch of lime powder is to put a small handful into water: if there is a rapid rise in temperature it will indicate a good quicklime which has been unaffected by the atmosphere.

Hydrated Lime

Many modern manufacturers now supply hydrated lime in bags in a similar manner to cements. This lime is slaked by a special plant at the works, and supplied as a fine, dry powder ready for use. By using this

lime the risk of incorporating unslaked quicklime particles is removed, and with it the chance of the work " blowing " or " popping " after completion through the delayed slaking of these particles.

Ordinary lime depends for its setting and hardening qualities on the recombination of the lime with the carbon dioxide which was driven off in the burning. Thus, while plastering will set in reasonable time as it has a large surface exposed to the air in comparison with its thickness, several years will elapse before the lime mortar in a wall has been able entirely to carbonise.

Hydraulic Lime

For ordinary builder's mortar it is best to use a hydraulic lime, which is one containing silica and alumina in addition to calcium oxide. These limes slake very slowly, but do not require exposure to the air to harden, depending for this largely on the hydration of the silicate. They are sometimes called *Lias*, and when very hydraulic are used in positions where the setting has to take place in water. But the really hydraulic blue-lias limes are associated with definite districts, and the colour is no guide to their hydraulic properties.

The limestones which produce hydraulic limes contain in themselves the silica, alumina, and iron oxide required, and have not, as has Portland cement, to be specially mixed before burning, and thus when ground are really of the nature of a natural Portland cement.

This may be seen by comparing an analysis of the two materials :—

Hydraulic Lime		*Typical Portland Cement*	
Calcium oxide	67·0 per cent.	Calcium oxide	63·3 per cent.
Magnesium oxide	1·0 ,, ,,	Magnesium oxide	1·3 ,, ,,
Silica	17·5 ,, ,,	Silica	22·7 ,, ,,
Iron oxide	2·4 ,, ,,	Iron oxide	3·3 ,, ,,
Alumina	7·2 ,, ,,	Alumina	5·5 ,, ,,
Water, etc.	4·9 ,, ,,	Sulphur anhydride	1·9 ,, ,,
		Other ingredients	2·0 ,, ,,

Pozzolanas

Pozzolanas are materials which can be added to ordinary lime in order to render it hydraulic.

Natural pozzolana is found near the town of that name, and consists of volcanic sand from Vesuvius. Other similar material has been found near Andernach in Germany, where it is known as *trass*. Artificial materials include such things as pounded brick, burnt clay, and yellow and red shale from the Scottish shale-oil industry. These materials are not in the nature of fillers, for they actually combine slowly with the lime to form a cement, and it is the fact that the setting action is independent of the action of the air that renders the mixture hydraulic. Pozzolanas have not been widely used in this country, but the trass pumice rock from Germany, when ground and mixed with Portland cement, has increased the resistance of concrete to sea water, and burnt clay added to Portland

cement produces a concrete with a higher fire-resisting quality than one made in the usual manner. Tests carried out by the Building Research Board on blocks composed of 1 part of a mixture of 40 per cent. burnt clay and 60 per cent. Portland cement, 1½ part of crushed red brick, and 3 parts of coarse broken brick, showed that they lost only 40 per cent. of their original crushing strength after being subjected to a heat of 800° C.

Selenitic Lime

This material derives its name from selenite, the chemical name for gypsum. Keene's is one of the best-known gypsum cements, and the general method of manufacture is to burn the gypsum to a red heat, then drop it into a solution of alum. When dried, it is reburnt at a high temperature, and finely ground.

There are many proprietary brands of selenitic lime on the market, nearly all based on burnt selenite, with other admixtures, several of which are patented. It is best to follow the makers' instructions to obtain satisfactory results in their use.

CEMENTS

Portland Cement

Portland cement can be produced from any suitable materials containing lime, silica, and alumina, the most common being chalk or limestone, and clay or shale. Portland-cement works are usually situated in districts where these materials are found near to one another, such as the banks of the Thames or Medway, and Cambridgeshire and Bedfordshire ; while near Rugby, and in Derbyshire and also South Wales, the Portland-cement works employ the limestone and shale found together in what are geologically known as the Lias deposits.

Storage of Cement

Cement when delivered to a job must always be stored in a dry place, as it rapidly deteriorates if allowed to become moist. It is best to stand the bags on a raised platform, or on some damp-proof material laid on the ground. Cement which is lumpy from exposure will provide only a weak, slowly hardening concrete, but if kept quite dry Portland cement will last almost indefinitely without deterioration.

Setting

When mixed with water, Portland cement begins to harden, and finally becomes rock-like. The beginning of this process is called the "initial set," and the end the "final set." Cements are also known as quick- and slow-setting, according to the length of time they take, and a quick-setting variety can be slowed down by the addition of a small quantity of gypsum. An average cement should take about 2 hours to reach the initial setting stage, and 4 hours the final stage, thus allowing

the workmen time for placing the concrete or other mixtures in position before the setting begins. For under-water work or grouting, of course, a quick-setting cement should be used.

Rough Tests for Cement

The scientific testing of cement requires special instruments, and cannot be carried out on a job, but a few simple tests can be made by the foreman or clerk of works if the material delivered appears for one reason or another to be below standard.

The setting quality may be tested by mixing up a pat, using the minimum amount of water, on a sheet of glass until it is about 3 in. square and 1 in. thick. In 24 hours this pat should be hard enough to resist the impression of a thumb-nail, and in 48 hours it should be difficult to break in half. The pat must be stored the whole time in a moderately warm place under cover, for a temperature below 50° F. has a retarding influence on the setting of cement. An expansion test can also be made on such a pat of cement by boiling it in water for a few hours after it has hardened, and if the pat neither softens nor cracks it may be considered satisfactory. The old bottle test, which consisted of filling a glass jar with cement and deducing the expansion by the bursting of the jar, is unreliable, as the burst is often caused by the unequal expansion of the glass during the changes of temperature, and not by the cement. Other rough-and-ready tests which are sometimes made are all equally unscientific, and if the setting and boiling tests already referred to prove unsatisfactory, further tests should be undertaken in a laboratory by a properly qualified expert. See B.S. Specification for Portland cement No. 12—1931.

Rapid-hardening Cements

During the last few years a number of these finely ground cements has been put on the market, and their action should be clearly understood. Rapid hardening must not be confused with rapid setting, for the initial set of these cements is often slow, but as soon as they are set the hardening and consequent increase in strength takes place rapidly. At present no British Standard Specification covers these brands, but a mixture of 1 part cement to 3 parts sand should resist a tensile stress of at least 400 lb. per square inch after 24 hours, and 650 lb. per square inch at 7 days. A rapid-hardening cement, which generates more heat, is useful for concrete work when carried out during the winter months, for frost prevents setting of ordinary cement. It is also of great advantage to use such a cement where speed in striking the shuttering is essential, and for all precast work such as lintels and fencing-posts.

Other uses for rapid-hardening cements are in the construction of concrete piles and engine beds, or for road surfacing where long delays would cause public inconvenience.

Aluminous Cements or *Ciment Fondu*

These cements, which were discovered about 1908, are not true Portland cements, although they contain the same constituents. The proportions are, however, very different, the amount of alumina being nearly five times as great as in true Portland cement.

The approximate difference may be seen in the following table :—

	Portland Cement	*Alumina Cement*
Silica	22 per cent.	5–15 per cent.
Alumina	7 ,, ,,	35–45 ,, ,,
Iron oxide	3 ,, ,,	5–15 ,, ,,
Lime	63 ,, ,,	35–45 ,, ,,

Aluminous cement is manufactured by burning together lime and a mineral called bauxite—which is the ore of the metal aluminium—until fusion takes place as a molten mass. This solidifies when cold, and is then ground to a fine powder. The bauxite has to be imported, as the ore is found mostly in France, and special machinery is required to pound up the exceedingly hard slabs of burnt material which the electric furnaces produce.

Aluminous cements are said to reach in one day the strength of ordinary Portland cement of 100 days; they are thus definitely rapid-hardening. But precautions must be taken in their use, as their rapid hardening generates heat, and this may evaporate the water in the concrete, and water must be ready on the job to keep the concrete thoroughly wet for at least 24 hours after placing. Ordinary Portland and aluminous cements must never be allowed to come into contact with one another, so that on a job, when both materials are in use, great care must be taken when changing over to clean all barrows, shovels, or mixers.

Aluminous cements are at present expensive, owing to the necessity for importing part of the material and the special plant required, but they undoubtedly have great advantages in modern building where a quick-hardening cement is needed.

White Portland Cement

The grey colour of ordinary Portland cement is due to the presence of oxide of iron, so that to produce a white cement the materials used must be almost free from this constituent ; and it is the care which has to be exercised in manufacture to ensure this which renders the finished product more expensive than the ordinary material. Both its storage and mixing are carried out in the same manner as the ordinary product, and it is employed almost entirely for facings or other features where the grey colour would be unsuitable.

Roman Cement

This is a cement manufactured from nodules of clayey limestone found in the London clay formation. These nodules are composed of half clay

and oxide of iron and half carbonate of lime. The colour is dark brown, and it is exceptionally quick-setting, and therefore useful for foundation work in waterlogged soils.

MORTARS

One of the uses of the limes and cements described is to make mortar. All mortars consist of a cementing material which is diluted by the addition of an inert filler such as sand or clinker, and they must be able to adhere to the stone or bricks and set hard.

Mortar sand must be free from clay, as this substance interferes with the setting of the mortar, and any sand containing clay must first be washed. If a small quantity of sand is shaken up in a glass of water and allowed to settle, the grains of pure sand will first be precipitated, and should a muddy-looking deposit afterwards form over them the sand requires washing before use. A moderately coarse sand, with grains of varying sizes and sharp edges, is best for mortar mixing, and pit sand is to be preferred to other varieties ; sea sand should be avoided in all cases, because of the presence in it of salt.

For ordinary brickwork, mortar may be composed of 1 part grey stone lime to 3 parts of sand.

If heavy weights are to be carried, 1 part lias lime to 3 parts of sand.

And for quick setting, and very heavy loads, 1 part Portland cement to 4 parts of sand.

The mortar should be prepared on a properly constructed deal platform or " bank," and measured in boxes or moulds. If mixing is done by hand this measured quantity of sand is piled over the slaking lime and left for sufficient time to complete the process before being mixed. With lime already hydrated, all that is required is to mix the sand and lime dry, and then add enough water to render the mass plastic. A few days should elapse before using the mortar so prepared.

A mortar mill should, however, be employed whenever possible, and is essential for large jobs, as it minimises the danger of unburnt or unslaked lumps in the mortar. Objection is sometimes taken to this method on the ground that it crushes the sand to a uniform size, which slightly reduces the strength of the mortar. But if clean, broken brick is added to the milling it will act on the mixture as a pozzolana, and assist hardening.

Cement mortar is prepared on similar wooden platforms, and used at once, as the setting commences directly the water is added. Good mortar should have enough water mixed with it to enable it to drop cleanly off the trowel without leaving a stain. Another test is to knead up, by hand, small balls of mortar which, if of the correct proportions, should not exude water on the surface. A weak cement mortar, composed of 1 part Portland cement, 1 part of slaked lime, and 7 parts of sand, can be used as a substitute for the usual lime mortar (2 to 1) in general work.

METAL SHOP FRONTS

CONSTRUCTION AND ERECTION

IN introducing this subject, it is most interesting to note that the fitting, assembly, and erection of metal shop fronts has become primarily the work of woodworkers. Those in this trade who have never done any work other than in wood, should find this short article of an instructive nature. The metal is first drawn on the wood core. After this operation, the joiner or woodworker takes over, and cuts and assembles ready for fixing.

THE METALS USED

The metals most commonly used are in the following order :—

Bronze.

" Staybrite " (stainless steel).

Aluminium and other white metal alloys are also used to an increasing extent.

Bronze and " Staybrite " have now become quite common in the shopfitting world.

Bronze

This is very popular because of its easy working in both assembly and fitting. With regard to the cost it is in fact no dearer than polished hardwood, and its durability is certainly of a high standard. If treated properly in its early stages after being fixed, it can be brought to a very rich shade of copper coinage colour, and so never gets that down-at-heel look a wood shop front does. It can also be kept bright, but this requires constant attention and cleaning.

" Staybrite " (Stainless Steel)

This is fast becoming a most popular metal for shopfitting, mainly because of its attractive appearance and its resistance against all weathers.

Many people will naturally think that this metal never requires attention. This is not quite true, as, in the case of stainless steel cutlery, it occasionally requires to be washed with warm water. Then it does not deteriorate in any way and keeps its original lustre.

SELECTION OF SECTIONS

Great care must be taken with this part of the work, as the indiscriminate selection of mouldings results in an imperfect job.

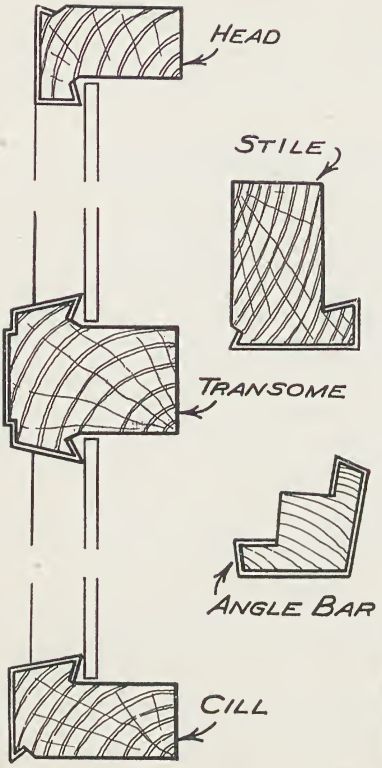


Fig. 1.—SECTIONS OF A SIMPLE METAL-FACED SHOP FRONT

Showing head or top rail, transome or intermediate rail, cill or bottom rail, stiles, and angle bar.

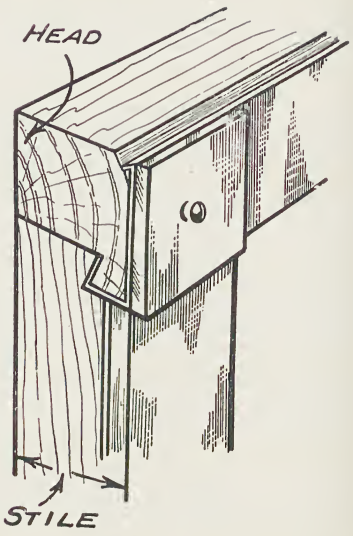


Fig. 2.—JOINT OF HEAD AND STILE COVERED WITH A FLAT PATERA

Fig. 3.—HANDRAIL BOLT BEING INSERTED FOR BOLTING MITRED JOINT

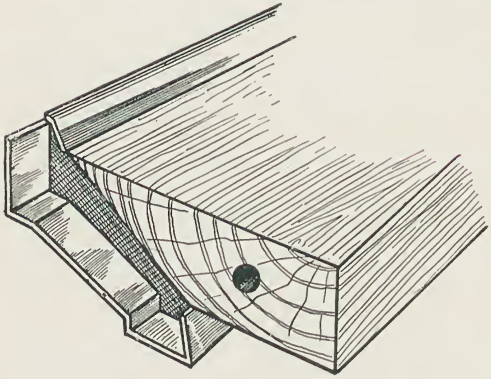


Fig. 4.—HOW WOOD IS CUT AWAY FOR SWEATING MITRED JOINT

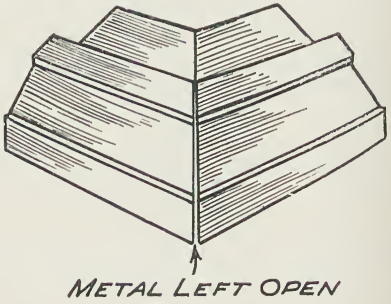


Fig. 5.—HOW TO UNITE MITRE FOR WELDING EXTERNAL ANGLE

In this case the wood is not cut away, but the metal is allowed to remain slightly open.

Let us take a simple shop front, the sections of which consist of head or top rail, transome or intermediate rail, cill or bottom rail, stiles, and angle bars.

For Head and Stiles

The head and stiles are generally of the same section, but as the edge of all metal mouldings is slightly rounded, it is better to cover the intersections with a patera, and as modern shop fronts are very simple in design, small, flat, or slightly raised pateræ are most acceptable.

For Transome and Cills

The transome and cills should be of a bolder nature, and should master stiles and angles at all points. This need not apply in all cases, as it will be seen by the illustrations that designs of all kinds and architects' details can be meshed together.

Mouldings can be mitred so that true intersections can be obtained as satisfactorily as in wood.

CUTTING OF METAL

When the joiner takes over rods, mouldings, and all details, especial care must be taken to see that the right lengths are cut. This is most essential, as in practice it has been found better to draw the mouldings in long lengths and so avoid the unnecessary wastage caused by having to allow at least 6 in. on every length drawn. This is to allow for the tongs of the draw-bench to be firmly fixed. Should several short lengths of a similar moulding be required, they are added together and drawn in one length.

The most suitable lengths used are between 12 and 14 ft.

Having checked all metal for the job, cutting is now proceeded with.

Mitred Joints—Cutting Bronze Metal

For a simple mitred joint an ordinary mitre cut can be made, though a saw suitable for metal must be used. In the case of bronze metal, the ordinary hand-saw is very serviceable and does not hurt the saw a great deal, though it requires constant sharpening.

The most serviceable tooth to use is about No. 10. It is much better, though, to get the specially tempered and sharpened metal handsaw.

Cutting Stainless Steel with Hacksaw

With stainless steel it has been found that only the specially hardened and tempered hacksaws can be used. These are made only by Firths, and no others are really serviceable. This makes it more difficult for cutting and mitreing unless an extra-large hacksaw frame is used. Quite a perfect cut can be made best by the use of the ordinary mitre template.

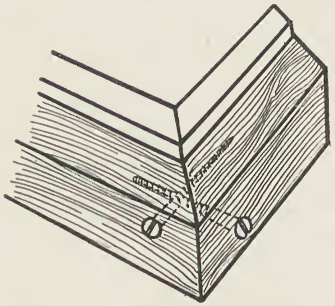


Fig. 6.—JOINTING INTERNAL ANGLE THAT WILL NOT BE SEEN IN FINISHED JOB

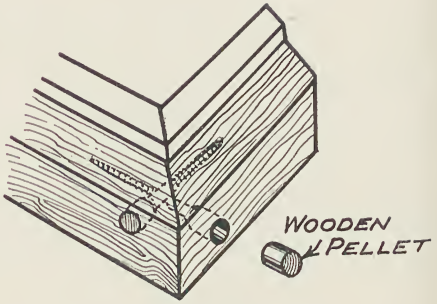


Fig. 7.—JOINTING INTERNAL ANGLE WHEN CORES WILL BE SEEN IN FINISHED JOB

Adjusting the Mitre

The cutting completed, it may be found necessary to touch up the rough edges of the metal, and also adjust any discrepancies in the mitre. This is done by filing. Here the mitre block can be conveniently used, but it will be found much better before doing so to apply a special facing so that no damage is done to the existing faces of the block itself.

The completed mitre will be as perfect as in wood.

Completing the Joint

While in wood, dowels or tongues can be used, we must now use handrail bolts. These are not foreign to wood joints, but not commonly used in ordinary mitres. Fig. 3 shows how to insert these. One nut of the bolt is circular and has slots for turning with a lever.

Making Sweated Joints

Before completing the mitreing by gluing and bolting, it is necessary to prepare for the following operation of sweating. For this purpose the wood must be cut away so that solder and small fillings of metal can be inserted. The binder, or some part of the metal invisible to the eye when fixed, is cut away, namely in cills—the underside; in transomes and head—the top (Fig. 4). This enables small particles of metal, about $\frac{1}{2}$ in. by $\frac{1}{4}$ in., to be dropped in together with solder. A great point to be noted here is that the wood being cut away from the back prevents any breaking of sweated joints owing to any dampness that may cause the wood to swell and so break the face of the joint. This might otherwise happen, especially in the cills of a shop front much exposed to the weather. The inside of the metal where the core is cut away must be cleaned so that the solder will run and unite, making a perfect joint. In the unhappy event of the fixer finding any defective joints or mitres in his job, it is a difficult matter for him to get over, and the best method is to

cover up such defective joints with a patera, although it naturally follows that corresponding joints would have to be covered with similar pateræ.

The Welding Method

Another method of uniting angles is by welding. This has not been used until lately to any great extent, but is now becoming very popular, as the metal is really and truly united. It is not necessary in this case to cut the wood away, but rather to let the metal remain slightly open. This allows the flame to pass through and complete the joint.

If no space were left for this joint in the mitre, the metal when heated would expand and curl, and it would be impossible to make a good joint.

Care must be taken that the oxy-acetylene flame, being of such intense heat, does not thin out the metal too much, and also care must be taken not to burn the wood behind the metal, as this causes the metal to become springy on its core, and in a very short while to break and produce a bad joint.

These methods of jointing are carried throughout on all external angles.

Jointing Internal Angles

It is not the practice to sweat or weld these, nor is it necessary to use hand-rail bolts except in the case of very flat angles. They can be put together by the use of ordinary wood screws through the back of the cores. If these cores are seen in the finished job, it will be better to sink slightly and insert a wood pellet.

If the joints are made in the shop, it is important to fix stout rough wood braces to ensure that no movement is made whilst en route to the job, and, in fact, these braces should be left in position until ready for glazing.

Joints to Assemble on the Job

A given run of a shop front may be too extensive for complete assembling in the shop, owing to the difficulty of transport after. In this case leave the least obtrusive of the joints for final assembly on the job. It must be an internal angle that will not need sweating.

ERECTION OF SHOP FRONT

This article attempts to deal only with general joinery as it applies to metal work. We will now deal with the general assembly and fitting together of a metal shop front, taking as an example a small double-fronted shop. Details of this are as follows :—

Fascia.—Drawn metal surround with glazing fillets for face glazing.

Sunblind Box.—Complete with bronze metal lath and edgings.

Shop Front.—Consisting of head, transome, and cills, upright bars, and tracery work above transome.

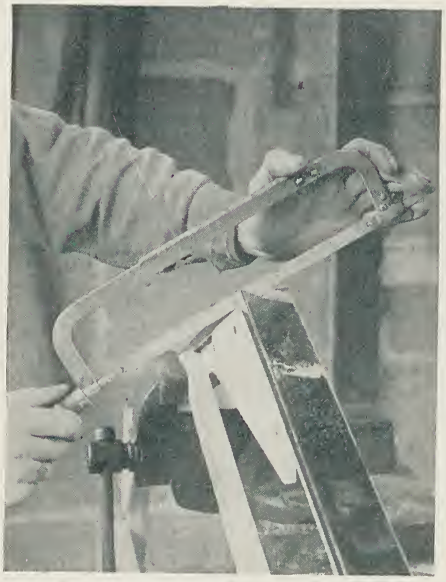


Fig. 7A.—CUTTING MITRE OF STAYBRIGHT WITH FIRTH'S HIGH-SPEED HACKSAW BLADE

Fig. 7B.—CLAMPED MITRE OF TRANSOME, SHOWING GAP PRIOR TO WELDING

Gap allows for expansion.

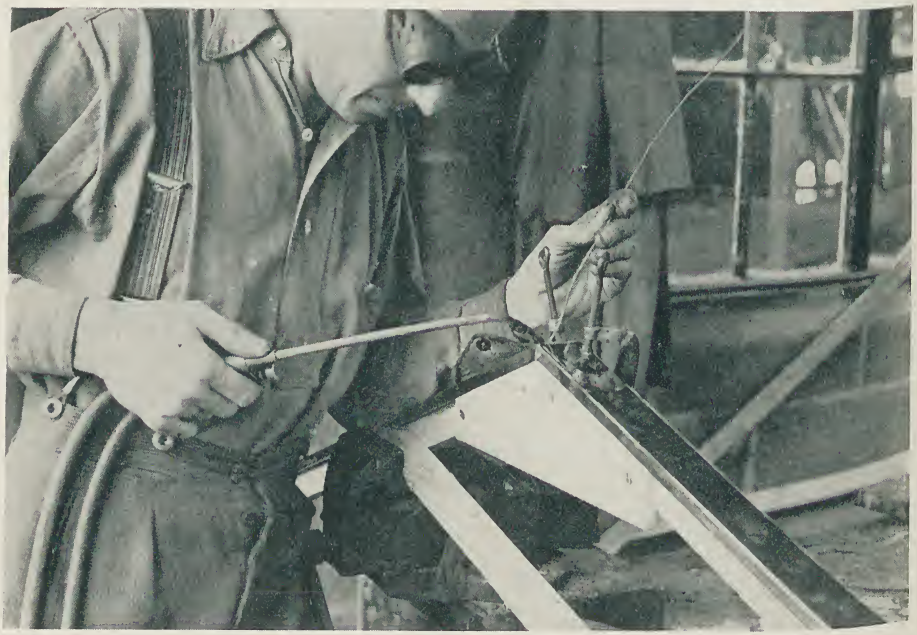


Fig. 7C.—WELDING TRANSOME RAIL OF SHOP FRONT

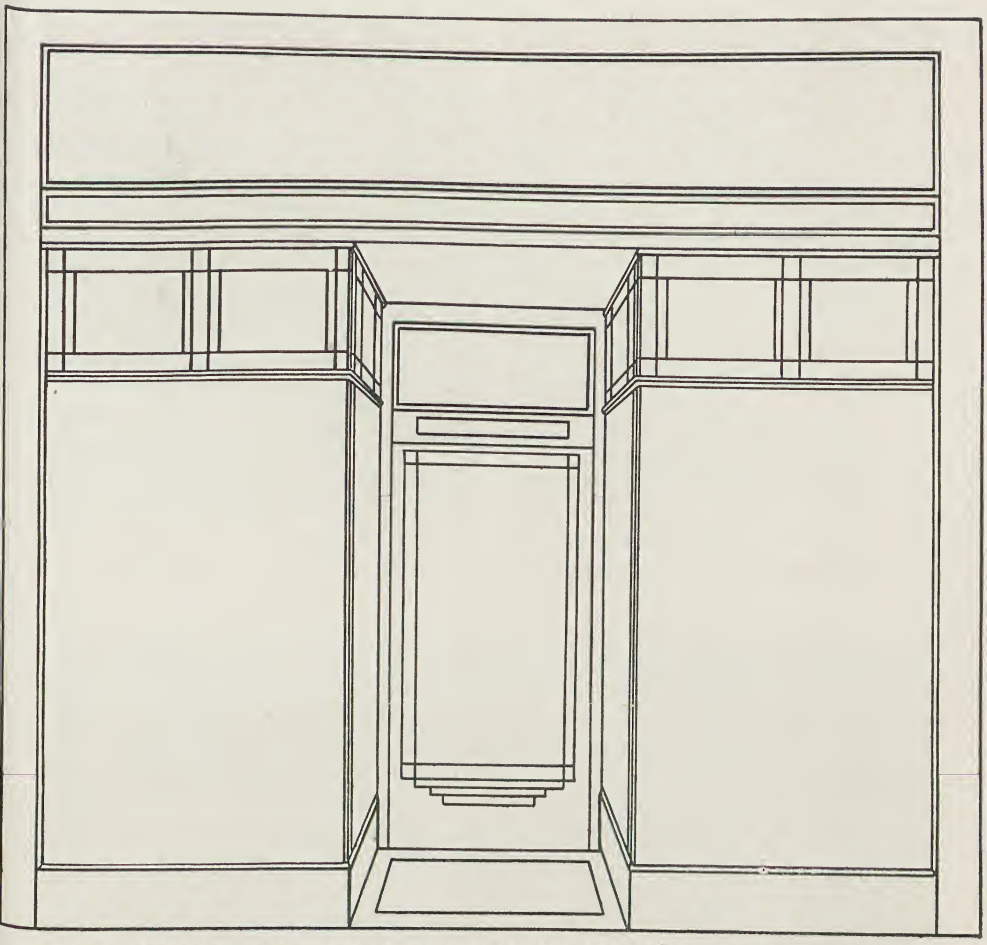


Fig. 8.—SMALL DOUBLE METAL-FRONTED SHOP, THE ERECTION OF WHICH IS DESCRIBED IN THIS ARTICLE

How Metal Work is Shown on Setting-out Rod

To begin with, all metal work is denoted on setting-out rods by a double line and etched in either a yellow or red pencil.

Simple Assembly of Sashes

The cill is fitted up as before described, and the transome and head are fitted on top, working from the rebate, or glass, sizes, as it is most essential that no alteration should have to be made when a fixer is handling the job.

The mitreing and sweating completed, next fit the stiles and angle bars into their respective positions.

Fig. 7D.—TRACERY BARS

Showing tongue joint to transome and halved joint to tracery bar.

Fig. 7E.—TENONING INTO TRACERY BAR

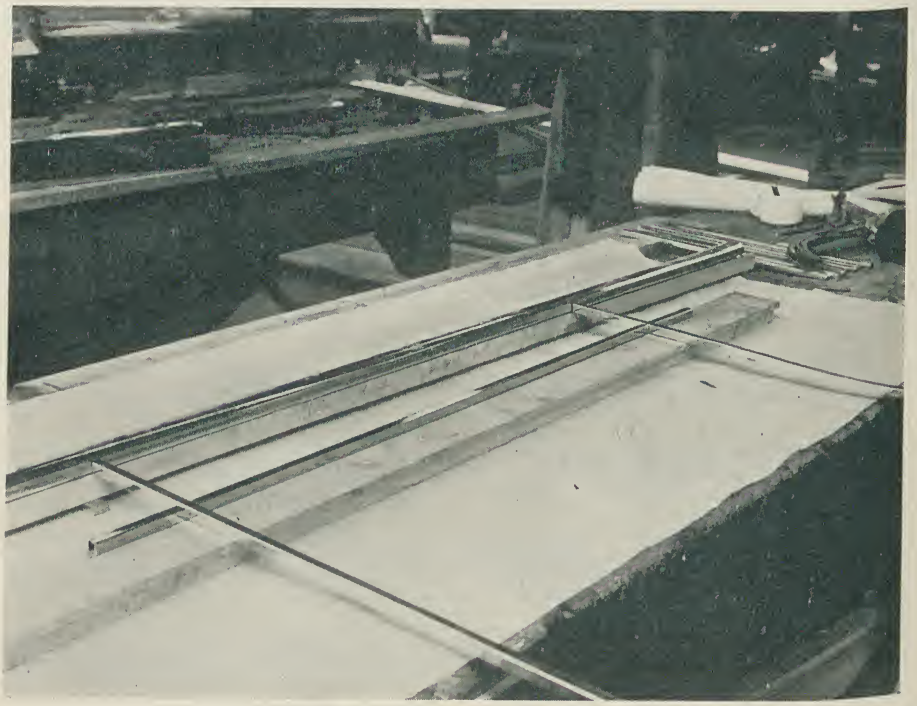


Fig. 7F.—TRACERY BARS TO TRANSOME COMPLETELY ASSEMBLED

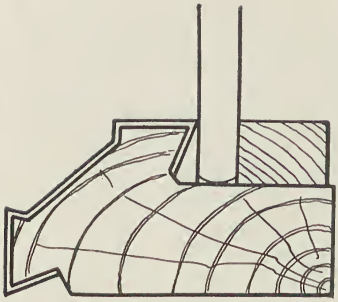


Fig. 9.—ALL METAL WORK IS SHOWN ON SETTING-OUT RODS BY A DOUBLE LINE

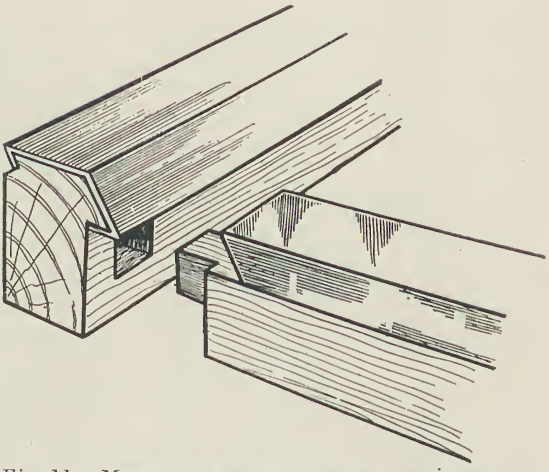


Fig. 11.—METHOD OF FITTING STILES AND BARS INTO CILL AND HEAD

Metal bar cut to fit neatly on metal rail, and wood cores cut to form stub tenon.

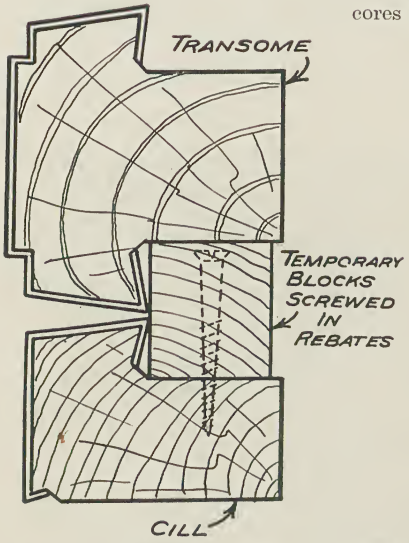


Fig. 10.—ASSEMBLY OF CILL, TRANSOME, AND HEAD WORKING FROM THE REBATE SIZES

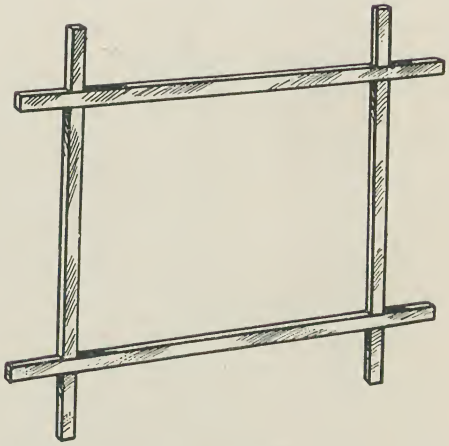


Fig. 12.—TUBULAR GRILLES FOR TRACERY WORK, AS MADE BY METAL WORKER

Fitting Stiles and Bars into Cill

To fit stiles and bars into cill, cut the metal bar to fit neatly on the metal rail, allowing the wood core to run on and so form a small stub tenon into the cill.

Cutting Metal to Form Tenon

When cutting, it is best to just cut through the metal and tap this off, so allowing easy working for the forming of the tenon.

In the small front we are describing, this entails stubbing into cill four stiles and two external angles.

Tenoning into Transome

Now take the height of glass and mark off the length of bar for tenoning into the transome. Care must be taken to see that the glass sizes again are strictly adhered to and due allowance made for glazing.

Fitting Bars into Head

The bar is tenoned in a similar manner as for the cill, and this is repeated again for the bars above transome and into head.

Cutting the Tracery Bars

Next cut the tracery bars. These can be made in several ways, the following two being most used.

Tube Tracery Work

The tube tracery work is fitted together by metal workers, who allow enough for fixing into the sashes. This enables the glass above transome to be in one sheet. It will be seen that the method of fixing these bars into the upper part of the sash is by allowing a thin portion of the metal to drop into the rebate and be fixed with a screw.

T-bar Tracery Work

This method is used a great deal, the only drawback being that the glass above the transome has to be fitted in several pieces. This makes a great deal of work for the fixer.

Generally, T-bars are of a small drawn section with the lay bars slightly deeper than the uprights, the reason being to avoid all slightly rounded edges making faulty intersections.

Halving Bars Together

The bars should be cut off to approximate lengths, both lay and upright, and marked for halving together.

A Caution as to Fitting

A point of care to be taken is to avoid getting the width of the metal too tight, otherwise when fitted together it will cause the tracery bars to be bowed and so cause breaking of glass.

Cutting and Assembling Grilles

The right size of grilles should now be taken and cut in a similar way for stiles in the general shop-front work, allowing the wood core to enter

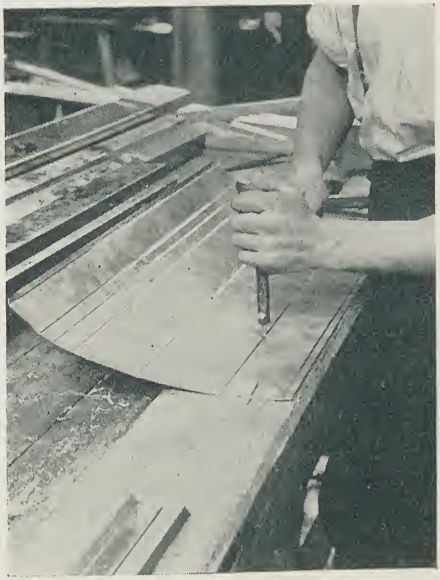


Fig. 12A.—HAND-SCORING METAL BEFORE FOLDING IN MACHINE

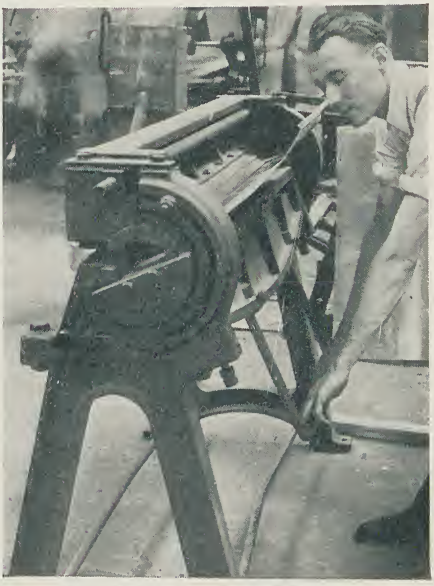


Fig. 12B.—FOLDING METAL FOR ANGLE BAR

Fig. 12C.—FITTING FOLDED METAL ON TO WOODEN CORE

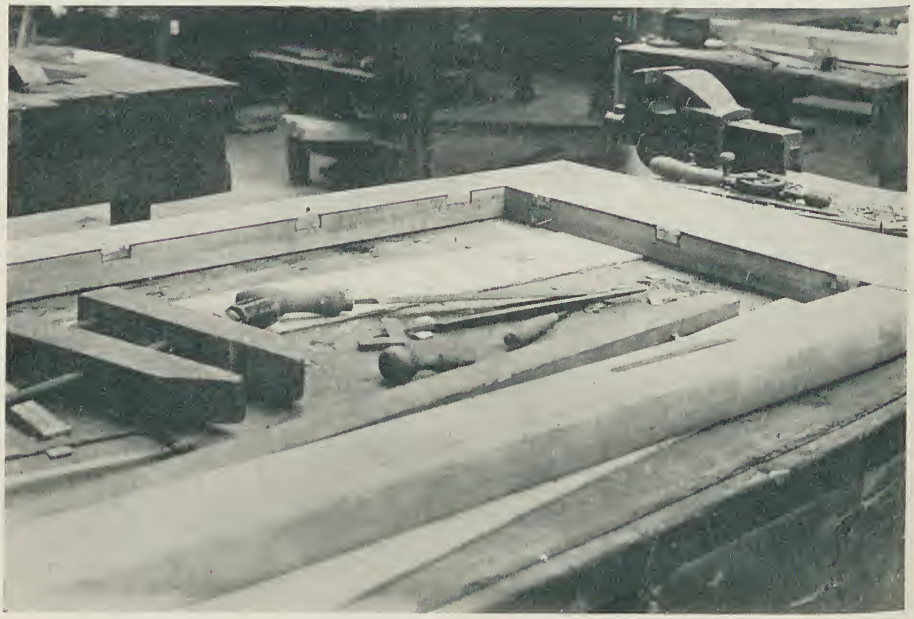


Fig. 12D.—METAL-FACED SHOP DOOR
This shows the method of fixing metal to the woodwork.

Fig. 12E.—METAL DOOR FRAME
Filing the welded joints.

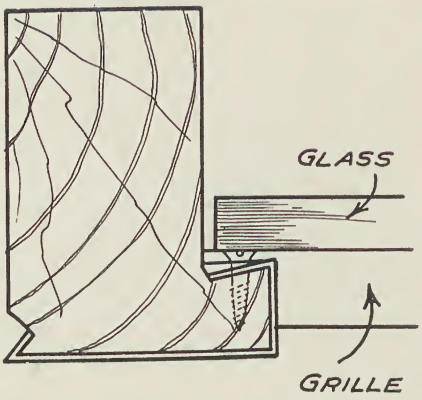


Fig. 13.—METHOD OF FIXING TUBULAR GRILLE TO STILES

This type of tracery work allows the glass above the transome to be used in one sheet.

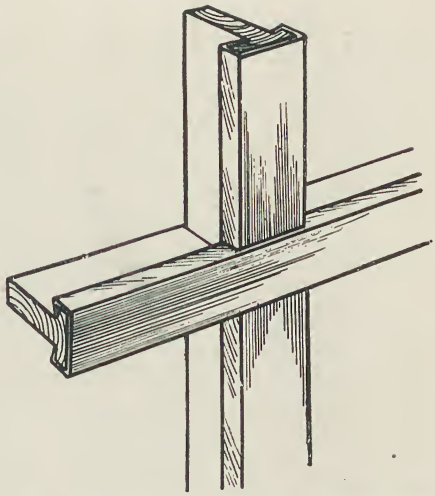


Fig. 14.—T-BAR TRACERY WORK WITH WOOD CORE

Note that the lay bar is slightly deeper than the upright.

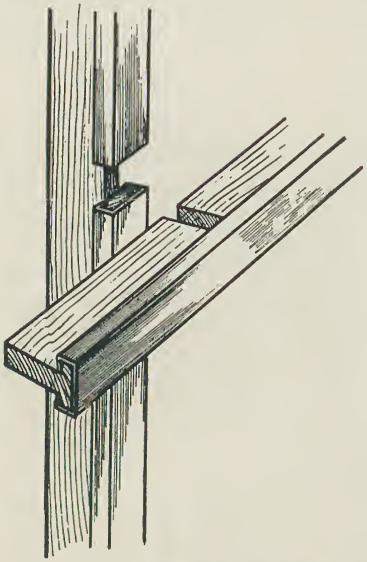


Fig. 15.—SHOWING HOW BARS OF T-BAR TRACERY ARE CUT FOR HALVING TOGETHER

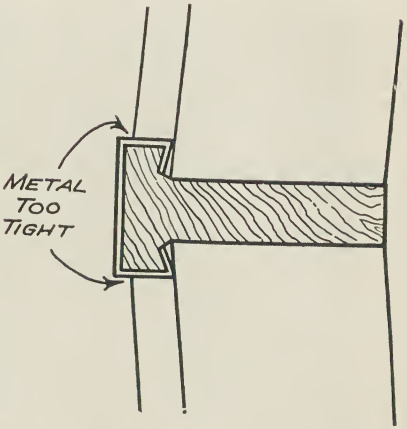


Fig. 16.—A FAULT IN T-BAR TRACERY THAT CAUSES BENDING OF BARS AND BREAKING OF GLASS

into the rebate and so allow for screwing. If necessary, they can be stubbed into the rebates, but by doing this the drawback is that the assembly of the upper part of the front must be done simultaneously

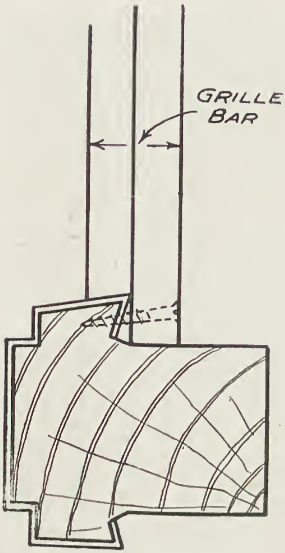


Fig. 17.—FITTING T-BAR TRACERY TO SASH

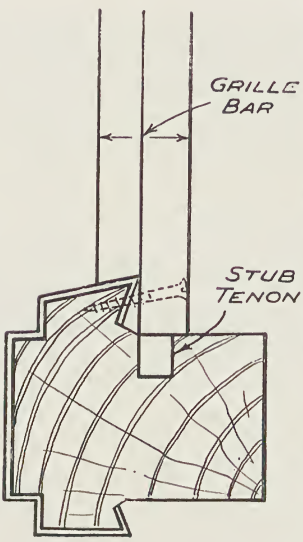


Fig. 18.—ANOTHER WAY OF FIXING T-BAR TRACERY

with the fixing of the grilles.

Erection of Upper Part of Front

We now come to the erection of the upper part of the front, which should, if possible, be done in the shop as it simplifies fixing considerably.

The stiles and angles should be glued into transome and screwed in the manner shown, the head being fixed in a like manner from the top. Good braces should be fixed so that no chance of racking occurs in transit or while being fixed in position on the job.

This completes the general assembly of shop-front sashes, except in cases where fixing stiles are required. These can be prepared by the use of a drawn moulding or by metal applied by means of screws, which, of course, should not be seen when job is fixed.

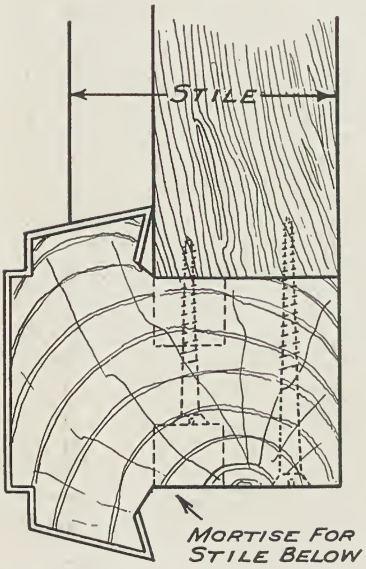


Fig. 19.—FITTING STILE TO TRANSOME

In most cases fixing stiles are required, as sites are usually a little out of line and plumb, and so these make it possible to get a square erection of the front itself.

Fitting Blind Box

Fitting of the blind box is done similarly as for wood in general shop-fitting, except that the mouldings supplied are of metal. The box usually comprises bottom, back, top, and cheeks. We will assume that the blind box in this case is fixed under the fascia, and sections used. The cores of applied mouldings are grooved to be fixed to the

Fig. 19A.—METAL SHOP-DOOR HANDLE
Drilling with electric drill.

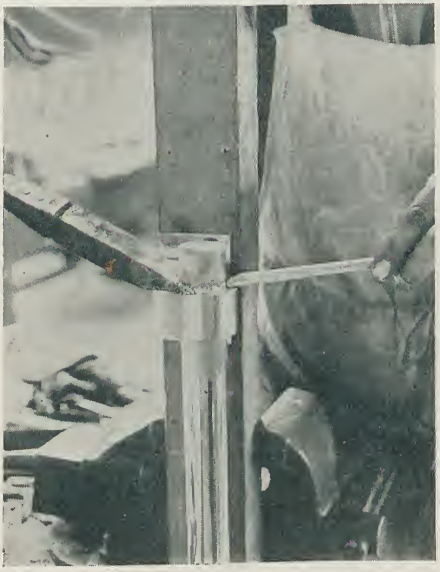


Fig. 19B.—SWEATING METAL SHOP-DOOR HANDLE

Fig. 19C.—BLIND BOX, SHOWING ZINC LINING TO MAKE IT WATERTIGHT

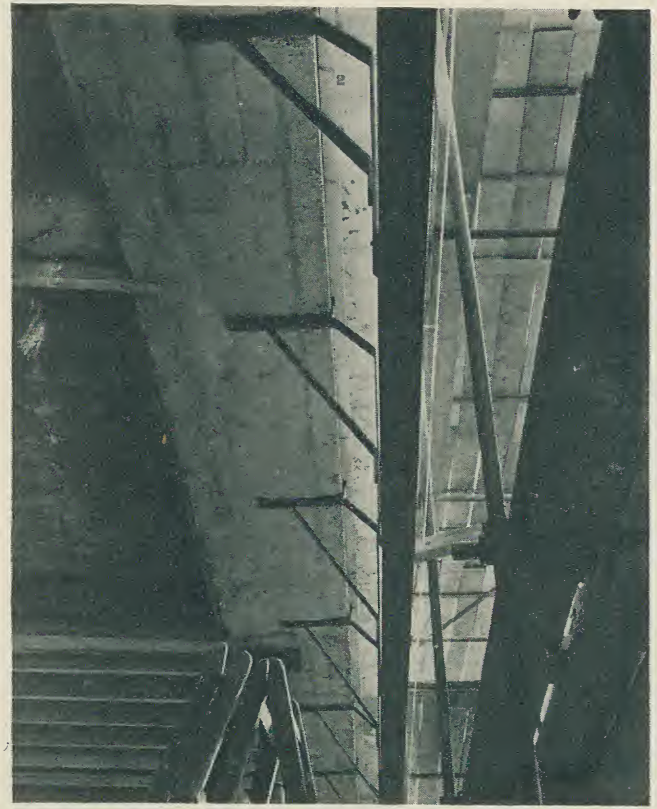


Fig. 19D.—ERECTING FASCIA

Underside of shop front, showing angle irons fastened into concrete.

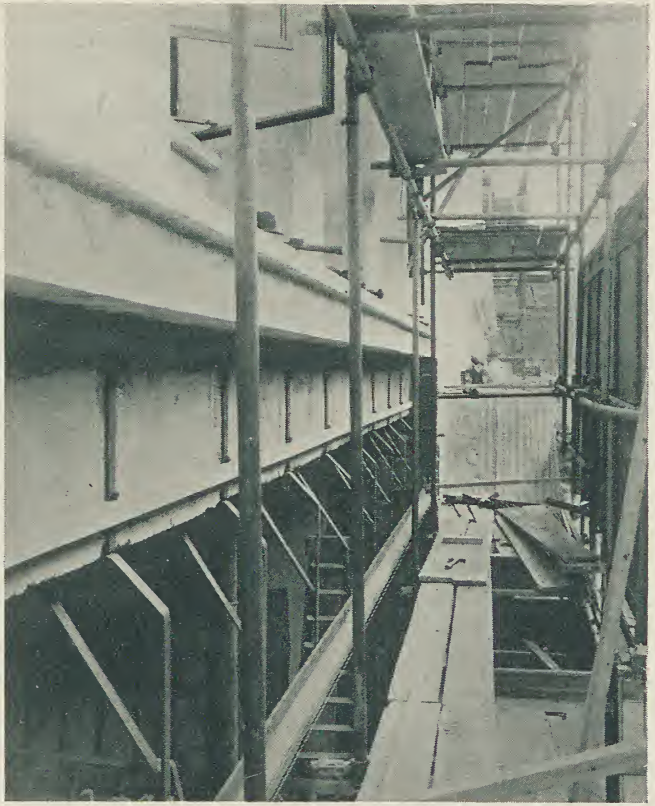


Fig. 19E.—ERECTING FASCIA

Angle irons and metal holder ready for fascia board.

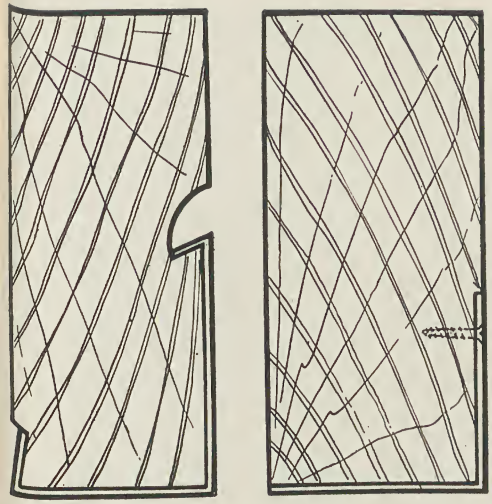


Fig. 20.—TYPES OF FIXING STILES

Showing a drawn section and an angle section screwed to wood stile.

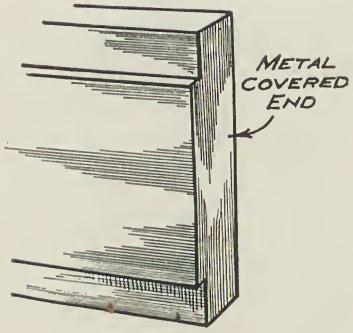


Fig. 22.—BLIND LATH COVERED WITH METAL AT END

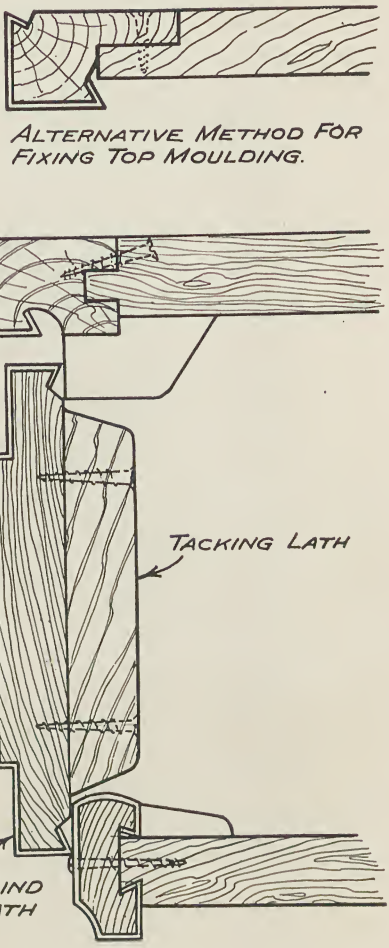


Fig. 21.—FITTING OF THE BLIND BOX

Showing an alternative method of fixing the top moulding.

box. This is done after the moulding is drawn, as it tends to weaken the core if done beforehand, and so crush in the process of drawing the metal on to the cores.

The method of fixing the top mouldings to the box is by screwing from the back or the top. The bottom striking fillet is more often screwed from the front with raised head screws. If the blind roller is required of an extra-strong calibre or is exceptionally long, that is, say, 16 ft. or over,

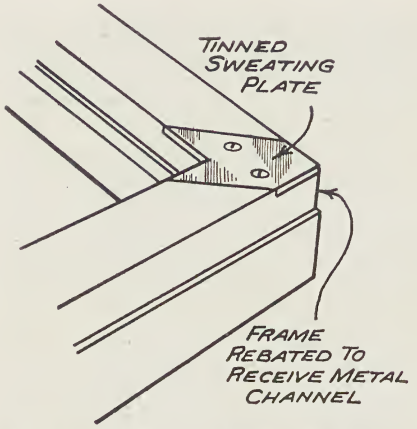


Fig. 23.—MAKING UP FASCIA BY APPLYING METAL TO FRAME

Note frame rebated to receive metal facing, and tinned sweating plate let in and screwed to corner of frame. See also Fig. 24.

it becomes necessary, in order not to have too large an opening, to do this, and so avoid the use of a large-section lath.

Type of Lath to Use

The reason for this is that metal laths are so heavy that when in use they are inclined to sag badly, and when pushed up do not fit into the box. Therefore, it is better to get the lightest section possible combined with strength.

The tacking fillet is screwed on the lath in the ordinary way, care being taken to give sufficient camber, so that when fixed it will drop to a normal straight line, and so obviate any sag afterwards.

Screwing on the Lath

Great care should be taken when screwing on this lath that the screws do not penetrate the wood and injure the back side of the metal. It is most difficult to get these marks out satisfactorily.

Proper Length to Cut Lath

The lath should be cut to length, due allowance being made for play, approximately $\frac{1}{4}$ in. either end, and stopped. For a good job the ends should be plated. The joiner first cuts the lath to the correct length, and inserts small sweating plates (already tinned), then the metal-worker fits in a piece of similar metal to the blind lath, sweats it into position, and polishes it off.

Methods of Fitting Fascia

Several distinct methods can be used. Wood frames can be made and angle-metal screwed on. Otherwise, drawn sections can be used on light back-frames. The choice, of course, is left to the designer of the fascia or to the shop-fitter's own fancy.

Applying to Wood Frames

If applied, the frame is made up complete in the usual manner with outer and inner edges rebated to take the angle or channel. A point to note here is that it is considerably cheaper when applying metal, to screw on, if possible, and to keep the screws hidden.

The metal is cut as previously explained and fitted on to the frame,

Fig. 23A.—ERECTING FASCIA

Front of shop with shop-fitters' tubular scaffolding in position for erecting fascia.

Fig. 23B.—ERECTING FASCIA

This shows the fascia frame being hoisted into position on shop front.

Fig. 23C.—TIMBER FASCIA FRAME, SHOWING GENERAL CONSTRUCTION

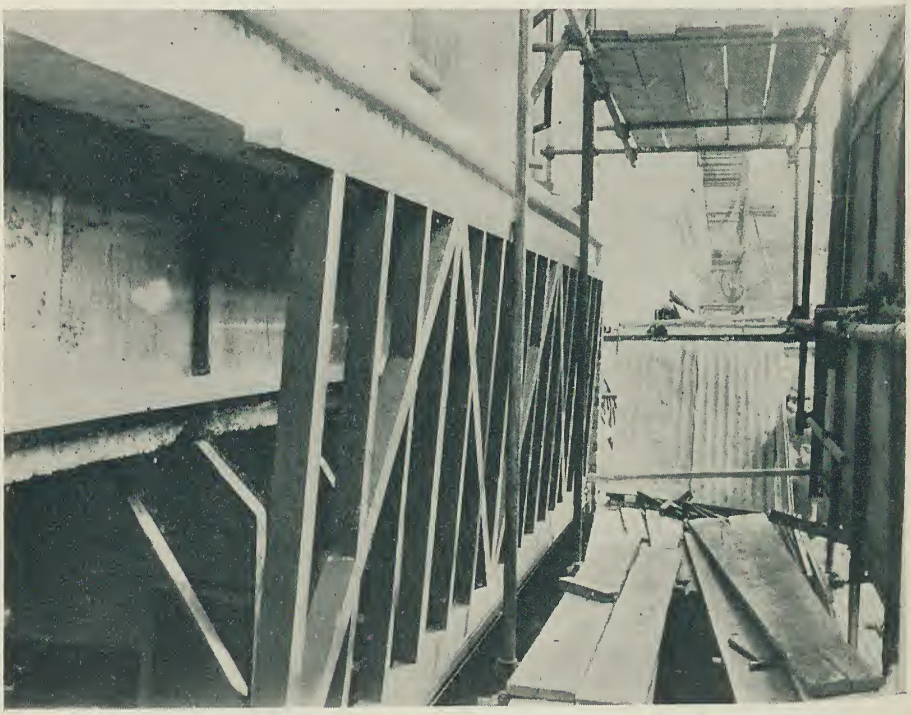
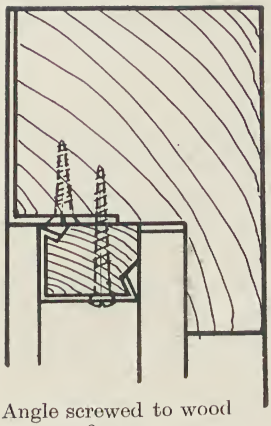
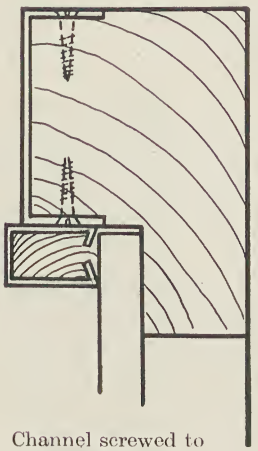


Fig. 23D.—FASCIA BOARD IN POSITION, HELD BY ANGLE IRONS



Angle screwed to wood frame.



Channel screwed to wood frame.

Fig. 24.—ONE METHOD OF MAKING UP FASCIA

By this method, the frame is made up complete with outer and inner edges rebated to take the angle or channel, and a small tinned plate let in at each corner, as in Fig. 23. The metal angles or channels are then screwed on, as seen above, and the metal-worker completes the job by sweating or welding.

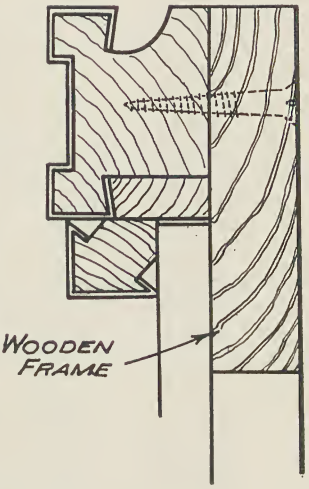


Fig. 25.—ANOTHER METHOD OF MAKING FASCIA

Drawn sections screwed on to light back frame.

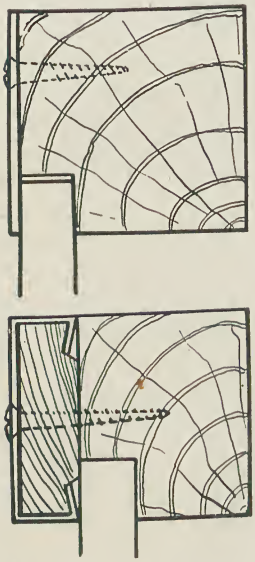
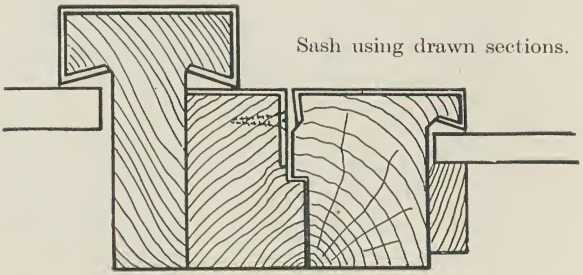
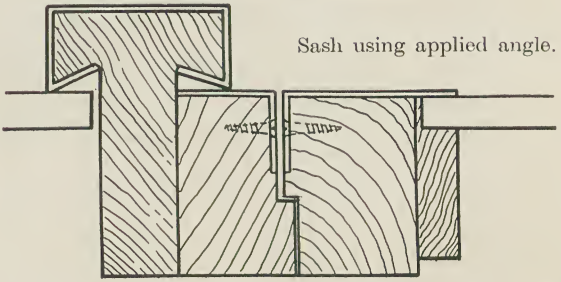


Fig. 26.—A THIRD AND CHEAPER METHOD OF MAKING FASCIA

Using either flat strips of metal or flat drawn mouldings screwed to wood frame.



Sash using drawn sections.



Sash using applied angle.

Fig. 27.—TWO METHODS OF DEALING WITH ACCESS SASHES

the only sweating being at the corners where a small tinned plate is let in. Then the metal is screwed on and a metal-worker completes by sweating or welding.

For glazing these frames in either cases a small, light metal section is used, which is cut, drilled, and mitred, and temporarily screwed into the frame with a few screws ready for fixing.

With drawn sections the process is similar to the preceding one, except that the mouldings are screwed to a light wood frame and are fixed from the back, using glazing beads.

A third and much cheaper method is to make up complete wood frames with rebates and screw flat metal on to the frames.

You will notice that here a choice can be made between the use of either a small flat drawn section or just sheet metal. With modern shopfitting this is generally done by joiners when fixing to allow for any small discrepancies that may occur on the site.

DEALING WITH ACCESS SASHES

In many of the larger arcade fronts or island sites these are necessary.

There are several methods of treating them, the two following being generally most acceptable to modern shopfitting.

A light wood frame is made with an inner door or sash. The outer frame is generally morticed or mitred together and covered with metal. The metal is exactly as for screwing on fascias. The metal is fixed by screws at the inner edge and is just sweated at the angle where necessary. In many cases the angle is inserted between two muntins or stiles in a front and does not show to any great extent. In this case, it would not really matter if it were left a clean mitre and not sweated at all. The inner frame or sash can be either of drawn section or angle metal applied.

With a drawn section, the mouldings are mitred and screwed together from the outer edge, the screws being sunk sufficiently to allow small wood pellets or stopping to hide these when completed.

With the sash where the angle metal is applied the wood frame is morticed and tenoned together and fitted in the outer frame, due allowance being made for the thickness of metal, so that when applied it will not bind and cause a deal of unnecessary work in easing sash when finally fitting.

The best size for these access sashes is approximately 5 ft. 6 in. by 2 ft., though these may be varied according to the height of glass in the lower portion of front or to suit various trades.

DAMP-PROOFING AND WATER-PROOFING

THE most common type of horizontal damp-course is one formed by laying two courses of slates breaking joint in cement, and is thoroughly efficient so long as the building does not settle and crack the slates. But most large buildings do tend to settle, and this tendency renders some form of non-rigid damp-course preferable.

Materials

A large variety of materials is available for use in this way, either singly or in combination, such as copper and lead sheets, asphalte mastic, bitumen and canvas, and bitumen and lead. These materials are obtainable usually in the following combinations : for vertical damp-proofing, asphalte mastic (which is also used horizontally and may be considered applicable in all positions), rolls of bitumen-impregnated canvas, lead and bitumen, or other material and bitumen, all of which are employed as horizontal damp-courses only.

As the damp-proofing element of all these is largely asphalte, a short description of this material is necessary. (For further notes see Vol. III, page 193.)

Asphalte Damp-proofing

Asphalte is a mixture of bitumen with a large proportion of other material. Natural asphalte is composed of bitumen and limestone, and the bitumen content of the mixture should be between 8 per cent. and 13 per cent.

In horizontal damp-courses the asphalte should have sufficient stability to prevent material squeezing under load, and the inclusion of a moderate proportion of grit of a suitable grading may with advantage be incorporated.

It should be particularly noted that in basements :—

(1) The asphalte should be adequately protected from damage after application ; and

(2) Concrete loading coats are necessary over horizontal work, preferably tied down under brickwork ; and

(3) The principal retaining walls should be on the interior side, so as to act as a buttress to protect the vertical asphalte against water pressure. The asphalte may, however, be applied

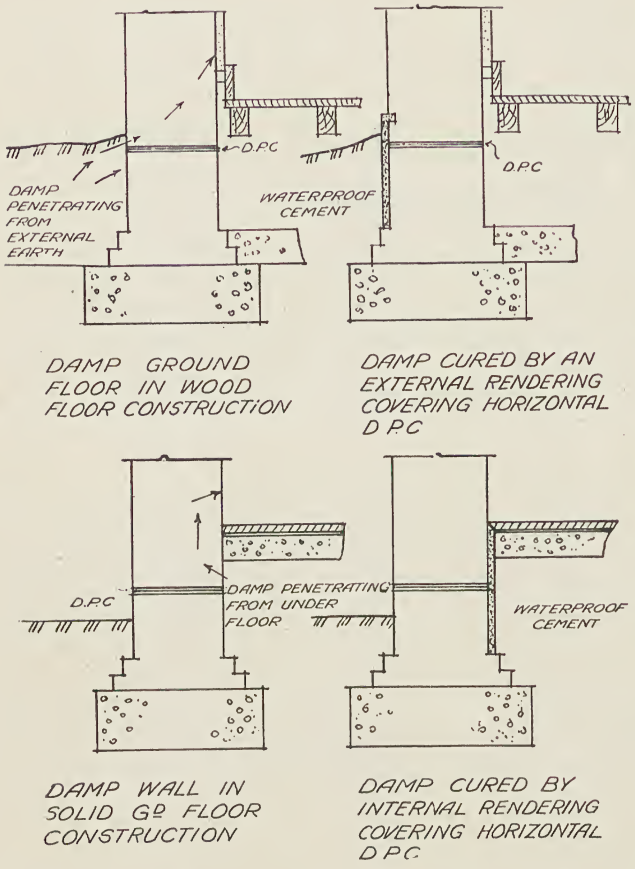


Fig. 1.—TWO METHODS OF CURING INEFFECTIVE DAMP-COURSE

to the outside of retaining walls.

The asphalte for damp-proofing arrives on the site as stamped blocks, bearing the sign of a Maltese cross and the letter D, indicating that it is specially made for damp-course work. Remelting must be carefully done, as the best asphalte is ruined by overheating, many of the constituents which give it pliability and waterproofing qualities being driven off. During melting, which is done in large cauldrons, the asphalte must be kept constantly stirred to prevent the heavier constituents sinking to the bottom.

Specification for Asphalte Damp-proof Course

The following specification should ensure a satisfactory asphalte damp-proof course, and is suggested by the Council of the N.A.M.M.

Horizontal asphalte damp-proof course above ground level, to be applied in one layer $\frac{1}{2}$ in. in thickness, the asphalte to be kept back $\frac{3}{4}$ in. from the face of the brickwork to allow for pointing.

All damp-course work below ground level, both vertical and horizontal, is applied in two coats. Horizontal damp-courses to have a total thickness of $\frac{3}{4}$ in.

Vertical asphalte damp-course to be applied in two separate layers, breaking joint to face of brick or concrete walls to a total thickness of not less than $\frac{1}{2}$ in.

All external angles to have asphalte fillets.

(The *Builder's Data Sheet No.* 5 illustrates the various methods of applying mastic asphalte as a vertical and horizontal damp-course.)

Bituminous Damp-courses

Under this heading may be included materials which are combined with bitumen and laid dry, such as bituminous felt, or bitumen and lead.

One advantage of these types of damp-course over the rigid varieties is that they respond to any slight settlement of the building without cracking. Two disadvantages have been noted after tests carried out by the Building Research Board: (1) the tendency for the bitumen to squeeze out under load, and (2) the slipping of the building on its foundations. The type of damp-course most affected in these ways under the test was one composed of a hessian core coated on both sides with bitumen. It should be remembered, however, that these hessian-base damp-courses are cheap, and may be found suitable for domestic work where heavy weights are not likely to be put upon them, provided that the material used for coating is a true bitumen and not one composed from coal-tar or pitch, which has little or no "life" after the evaporation of the volatile oils.

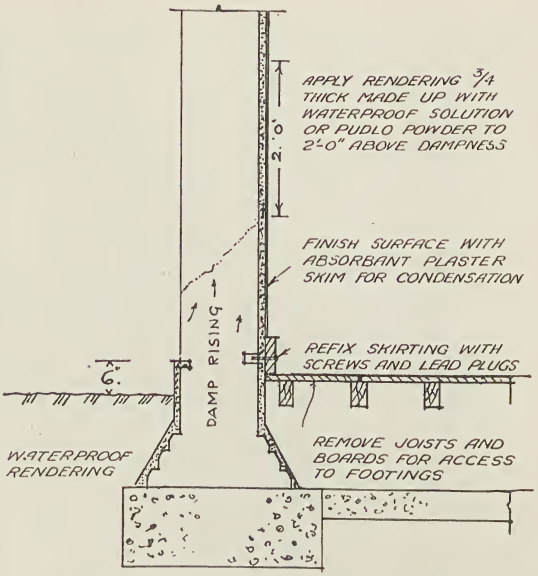


Fig. 2.—WATERPROOFING A WALL WITHOUT HORIZONTAL DAMP-COURSE

Lead and Bitumen

Another good pliable damp-course is one composed of lead and bitumen, which is at once tough and pliable. The weight of the lead used varies, and can be supplied up to 1 lb. per square foot, in rolls 24 ft. long.

How Bitumen Damp-courses should be Laid

When laying all bitumen damp-courses they should be set back ½ in. from the face of the wall, and the chase pointed up immediately in cement. All joints between the rolls should be lapped 2 in., but it is not necessary to seal them, as the weight of the building will do this.

Bitumen Felt

The cheapest form of damp-course which will pass the standard by-laws is one made like a bitumen roofing felt, only drawn out of the tanks with more bitumen left on each side, the rollers through which the sheet passes being left loose instead of set as they would normally be for the production of roofing felt.

Bituminous Asbestos

Another bituminous damp-course is composed of half asbestos fibre and half blended asphalte. The material is also made up with a laminated lead core, weighing 4 oz. per square foot. This damp-course has been tested by the Building Research Department, both for sliding and for load bearing, and the results were generally satisfactory, although owing to the nature of the materials the resistance to shearing was low.

One of the practical advantages of these various types of bituminous damp-course is the ease with which they can be handled. They are supplied in rolls cut to the various widths of walls from $4\frac{1}{2}$ in. upwards, and have only to be laid and unrolled on the brickwork. There is, however, on the market a bitumen or lead damp-course made in 3-ft.-long slabs, composed of two-ply bitumen and 6-oz. lead, which is laid breaking joint in the same manner as slates.

Ineffective Damp-course

The commonest cause of an ineffective horizontal damp-course is due to the level of the soil being above the damp-course level. This may happen either on the outside of a wall, or (if the ground floor is solid) on the inside.

The cure in both instances may be effected by using a waterproofed cement. In the one case the earth is dug back from the face of the wall, and the brickwork rendered down to the footings. The rendering must be carried up above the horizontal damp-course and tucked in as shown, to make a neat job. It is, of course, best to clear the earth away from the wall if possible, but this cannot be done in all cases, and the method shown will render the wall waterproof provided that the vertical cement is carried above the level of the soil some 6 in.

A similar method is employed for waterproofing the inside of the wall, but in this case the concrete must be cut up, the earth excavated from the inner face, and all made good afterwards. This is an expensive matter, and it should be remembered that the placing of a horizontal damp-course too low in a wall adjoining a solid floor is a difficult matter to cure satisfactorily.

Wall without a Horizontal Damp-course

The expensive and orthodox cure for this is to cut out the wall in short lengths and insert a horizontal damp-course in sections. The work is tedious, slow, and to be successful must be most carefully executed.

[*By courtesy of the Adamite Co. Ltd.*

Fig. 3.—BASEMENT WALLS OF MIDLAND BANK, POULTRY, LONDON
The concrete was waterproofed with "Colmanoid."

Another method which has been found effectual in many old domestic buildings is as follows. The earth is excavated down to the bottom of the footings, and the wall covered with a waterproof cement on the outside up to about 6 in. above ground level. The inner side is treated in a similar manner, the floorboards and joists next the wall being first removed. The waterproof plaster must be carried at least 2 ft. above the top of the damp level in the wall, and it is best to finish it off with a skin of absorbent plaster on the face to prevent condensation. When refixing the skirting board, this should be done with screws and lead plugs, to prevent the water seeping through at the screw holes.

WATERPROOFING

The various systems of waterproofing may be classified as :—

Surface coatings.
Incorporation with building materials.
Mackintosh-sheet process.
Mastic substances.

Surface Coatings

The surface coatings may be transparent fluates, which depend for their efficiency on combining with the calcium hydrates in the cements. There are many proprietary brands of coatings, the majority depending on silicate of soda as a base. Others consist of weak solutions of wax dissolved in petroleum spirit, linseed-oil solutions, or resin or synthetic gums. Some of these latter materials may fail after a lapse of time, owing to the alkaline action of the cement.

Incorporation with Building Materials

There are also many types of finely ground powders and liquids which can be incorporated in cement or concrete to increase their wet-resisting properties. Most of these are composed of colloidal clays, calcium hydrate, ground silicates, and felspars, while others are in the form of water-insoluble soaps, casein preparations, and calcium chloride. The action of some of these ingredients is negligible on the concrete itself, while others react chemically and form new compounds which resist the penetration of wet. Most of them are produced in the form of proprietary brands, and it is best to choose one from a firm of repute and use it in accordance with the manufacturer's directions.

Mackintosh-sheet Process

The mackintosh process consists in applying some elastic membrane continuously on the face of the damp wall, or between the layers of building material. This may be either a mastic poured into a cavity, a bituminous paper or felt, or a liquid sprayed on to the wall under pressure.

Mastic Substances

The mastic substances have already been described under the various forms of asphalte and bitumen, and are chiefly used for horizontal surfaces or vertical faces below ground level.

SOME WELL-KNOWN WATERPROOFERS

Some of the best-known waterproofing materials are "Pudlo," "Ironite," "Prufit," and "Colmanoid," but there are many other preparations which will be found equally effective each in its special way. A short description of those mentioned will, however, give a general idea as to the use of these preparations.

"Pudlo"

This is a white powder which is mixed dry with Portland cement before adding the sand in quantities of 5 lb. to every 100 lb. of cement by weight. It is claimed for this material that it reacts with the Portland cement and produces an insoluble siliceous substance, which during setting forms an impervious surface. The material also assists in render-

ing the cement mortar more dense, thus eliminating the voids, and so rendering the mass more wet-resisting. The setting of the cement is in no way retarded by the addition of " Pudlo," as has been proved by independent tests carried out by David Kirkaldy & Son.

" Prufit "

This material used to be known as " Ceresit," and is supplied in the form of a paste. It is mixed with water and brushed on, providing a dense waterproofing surface. Another similar compound supplied by the same firm is " Prufitol," a colourless liquid that penetrates into the pores of the damp wall, filling without discolouring the surface. This method will stop the penetration of beating rain, but will not withstand constant water pressure such as would be encountered in a damp basement ; for such a case " Prufit " must be used.

" Colmanoid "

A liquid chemical with a calcium base, which combines with the cement and crystallises simultaneously with it, forming a hard silicate. It is added while gauging the concrete in the proportion of 1 gal. of " Colmanoid " to 10 gal. of water, and is a valuable material to use in the construction of retaining walls and concrete tanks. The impregnated mortar should be applied in two coats both for coatings of $\frac{3}{4}$-in. and 1-in. thicknesses. The first coat should be scratched with a wire brush before the second is applied, and the finishing coat floated with a trowel. When " Colmanoid " is applied to a brick wall, all joints should be raked out to a depth of $\frac{1}{2}$ in. from the face, and a grout, made of 1 part " Colmanoid " and 3 parts water, should have enough Portland cement added to give the mixture the consistency of a heavy paint. The second coat should be applied within one hour of painting with this grout.

" Ironite "

" Ironite " is supplied in powder form to mix with Portland cement, and laid as a slurry by brushing on the walls. The proportions should be 25 lb. of " Ironite " to 75 lb. of cement, and the best method of mixing is to sprinkle the dry mixture of cement and " Ironite " into a pail of water until the right consistency is arrived at. Approximately 1 lb. of " Ironite " and 3 lb. of cement will be sufficient to cover a square yard of surface in one coat. It is advisable to damp the surface before applying the mixture, to ensure adhesion. " Ironite " is also supplied for waterproofing smooth surfaces in three-coat work. The fine powder is mixed only with water, and brushed on ; it is claimed for the mixture that it expands by a process of oxidisation and completely fills in the pores of the concrete or brick surface.

Rendering Walls with Stucco or Rough-cast

All walls which are to be treated for damp by these methods must first have every trace of previous rendering removed, and if the brick or stone is very smooth it should be hacked over and the joints raked out in order to form a good key. Before applying any rendering the whole surface should be washed down, to remove dust and prevent suction of water from the rough-cast into the dry walling.

Stucco is the name for a smooth rendering applied to a wall : it may be toned and mixed to a definite colour scheme, or so applied as to resemble stone ashlar treatment. Plain stucco is usually rendered in two coats to a total thickness of $\frac{3}{4}$ in., and for waterproofing may be made up as follows :—

3 parts of coarse washed sand,
1 part of Portland cement,

and an admixture of one of the waterproofing powders already mentioned.

A yellow-toned stucco with a rough surface may be made up with :—

5 parts of coarse washed sand,
4 parts of lime putty,
10 parts of pea gravel.

To the lime putty add 7 lb. of yellow oxide to each 10-in. diameter bucket of water used in gauging, and immediately before use throw in and mix one part of white Portland cement.

Pebble-dash

Pebble-dash is another form of rendering. If the work is carried out in a conscientious manner it forms a good waterproofer, but care must be taken to see that the pebbles used do not penetrate the undercoating ; should this happen they form a convenient path for the penetration of water to the brick face. Pebble-dash, like stucco, should be rendered in two coats, and while the second is still soft, washed pebbles or other selected aggregate thrown on and pressed in with the flat of a wood float. The quantity of pebbles is usually $\frac{1}{2}$ lb. to a square yard of surface.

The following is a typical specification for a dash face made up of Derbyshire spar.

Float the wall with a mixture of 1 part cement and 2 parts coarse sand. Well score the coat and lay over it a second composed of cement and sand (1 to 1) about $\frac{1}{4}$ in. thick, before the first coat has quite dried out. Mix up small broken spar or granite chippings well washed and damp and throw on to the cement surface in the manner of pebble-dashing.

Another method of rough-casting is to proceed as for stucco up to the completion of the first coat, and to mix in small pebbles or aggregate with the second before applying it.

COLOURING OF CEMENT AND CONCRETE

CONCRETE may be coloured either by the addition of colouring to the cement or by the application of a colour coat as a paint.

Colouring Cement

When colouring cement it is possible to achieve fair results by the use of easily purchased materials as listed below, but it is not easy to ensure a really intimate mixing with the cement, and modern practice favours the purchase of ready-coloured cement prepared by machine mixing.

Colour required	*Add*
Black	Oxide of manganese
Dark brown	Oxide of manganese and red iron oxide
Red	Red oxide of iron
Buff	Chromate of barium

Other colours can be obtained, but neither blues nor greens seem to be permanent, and in all cases there must be a maximum of 10 per cent. of added oxides or the concrete will be weakened.

If the purchase of ready-coloured cement is not possible, it is advisable to buy the colours from one of the many specialist firms whose experience allows them to guarantee uniform coloration and non-fading.

Prepared Coloured Cements

The difficulty of achieving really intimate mixing has led to the use of prepared coloured cements, machine-mixed, and guaranteed uniform throughout.

Colours obtainable include all shades of red, brown, purple, yellow, and black. It is probable that the more restrained tints are the most suitable for architectural work.

Applying Coloured Washes to Concrete

A coloured coating can be either sprayed or brushed on, brushing being preferable on the score of economy and of evenness of deposit. Errors can be rebrushed, but tears and runs with a spray, which is usually operated at some distance from the surface being treated, are difficult to rectify.

The commonest failing when applying coloured washes is due to lack of proper cleansing of the surface. Loose particles, if allowed to remain, take up the wash and later fall off, leaving patches. The wash must be given a few hours in which to set, and then be sprayed gently with water from a rose, this being repeated twice a day for at least four days, to ensure slow hardening.

The Dye Method

One of the oldest methods of colouring concrete is by dyeing the surface with a solution of iron sulphate crystals, the resulting brownish yellow shade being made darker by repeated applications.

Once again cleanliness is necessary, and the solution must be applied quickly and evenly or patches will result. Three-quarters of a pound of crystals to a gallon of water gives a light tone, and it can be applied conveniently by any spraying machine using *low* air pressure. Such machines incorporate a type of Roots blower feeding the air direct to the spray instead of from a pressure pump and reservoir.

Coloured Renderings

Of recent years a great deal of progress has been made in the application of coloured renderings of some depth to concrete, the rendering being made by the addition of water to prepared ready-mixed aggregate, cement, and colour.

The process is cheap. The original base concrete is picked clean and well moistened. It is first covered with a screed of rapid-hardening cement and aggregate about 1 in. in thickness, and whilst still workable is overlaid with only $\frac{3}{8}$ to $\frac{1}{2}$ in. of coloured rendering. This method gives perfect adhesion right through. The bulk of the cement particles are wirebrushed off whilst still soft, the underlying aggregate being then polished off by one of the various types of carborundum machines.

It is usual to reckon $\frac{1}{2}$ cwt. of the coloured material as sufficient to cover a square yard, but unless a depth gauge is used this is nearly always exceeded owing to a tendency for the men to work it too thick.

As with all renderings, it is best to keep these moist for some days after laying, so as to achieve a slow curing, thus avoiding cracking. Should there be any danger of staining at a future date from oil, a protective coat of beeswax or paraffin wax dissolved in petrol can be applied and rubbed off dry.

The Gunite Process

Yet another method of applying coloured or indeed any renderings is by means of the Gunite process. By this method, compressed air is used to drive a mixture of dry cement and sand through a nozzle, at which point water is added. The resulting mortar is deposited with a high degree of adhesion. Gunite coatings are extremely impermeable to water.

Digitized by:

ASSOCIATION
FOR
PRESERVATION
TECHNOLOGY,
INTERNATIONAL
www.apti.org
Australasia Chapter

**BUILDING
TECHNOLOGY
HERITAGE
LIBRARY**

https://archive.org/details/buildingtechnologyheritagelibrary

from the collection of:

Miles Lewis, Melbourne

funding provided by:

the Vera Moore Foundation, Australia